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14278

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE MARCH 1977/$1.25

16-PAGE BONUS!

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FRICTIONLESS DEVICE USES LED s

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TEST REPORTS

★ Sherwood S-7910 Stereo FM/AM Receiver

★ Empire 698 Manual Turntable

★ Ballantine 1010A Oscilloscope

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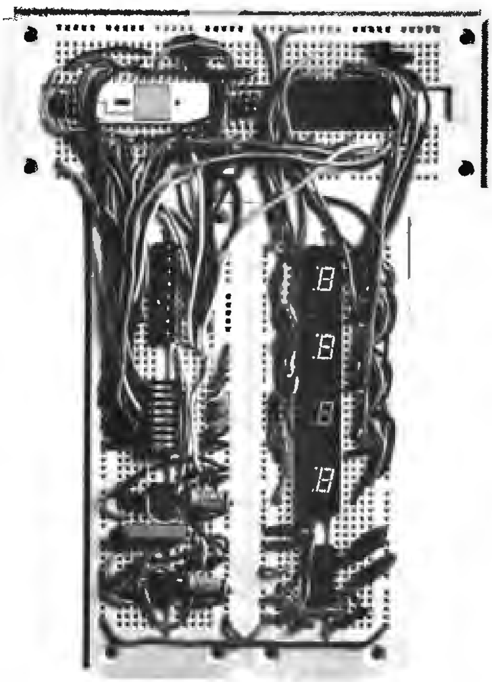
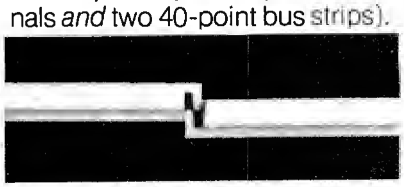
ANNOUNCING THREE NEW BREAKTHROUGHS IN SOLDERLESS BREADBOARDING.



Whether you design or build circuits for fun or for profit, you owe it to yourself to discover how fast and easy CSC solderless breadboarding can be. Now, more than ever. Because of three new breakthroughs in breadboard design. And our new EXPERIMENTOR™ sockets** that make the most of them.

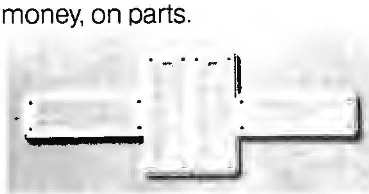
1. Price Who says a quality breadboard has to be expensive? For as little as $9.95, CSC's EXPERIMENTOR sockets let you design, assemble and modify circuits as fast as you can push in—or pull out—component leads. On a rugged one-piece socket with 550 solderless tie-points (94 five-point terminals *and* two 40-point bus strips).



Sockets lock together, snap apart to handle any size circuit with ease.

But don't let the low price fool you: EXPERIMENTOR sockets are precision-molded of durable, abrasion-resistant material, and feature CSC's non-corrosive, prestressed nickel-silver contacts for positive connections and longer life. All contacts are identified, too...with molded-in designations for easier circuit assembly and diagramming.

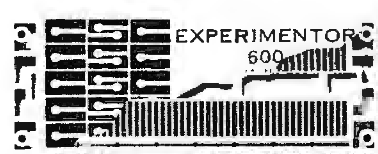
2. Compatibility CSC EXPERIMENTOR sockets end the "big-chip blues." They're the only ones with full fan-out capabilities for microprocessors and other larger DIP's, as well as 4-16-pin units. EXPERIMENTOR 600's 6/10" center is ideal for microprocessor's, clock chips, RAM's, ROM's, PROM's, etc. While EXPERIMENTOR 300's smaller 3/10" center is perfect for smaller DIP's. Both units, of course, accept transistors, LED's, resistors, capacitors, pot's—virtually all types of components with plug-in ease. As well as #22-30 solid hook-up wire for interconnections. Eliminating heat and lead damage to expensive components. And saving you more money, on parts.



Mix or match both models; arrange them vertically or horizontally.

3. Flexibility With CSC EXPERIMENTOR sockets, you can arrange your breadboard to suit your circuit...instead of vice versa. An exclusive snap-together interlocking system lets you instantly connect them. Vertically or horizontally. So you can mix or match 3/10 and 6/10" centers...expanding or contracting to meet your requirements.

CSC EXPERIMENTOR sockets can be used alone, or mounted on any convenient flat surface, thanks to molded-in mounting holes and vinyl insulation backing that prevents shorts. You can mount them with 4-40 flat-head screws from the front, or 6-32 self-tapping screws, from the rear. But however you use them, EXPERIMENTOR sockets are an unbeatable way to build and test twice the projects in half the time.



Both models feature 94 five-point terminals (vertical lines) and two 48-point bus strips (one strip shown).

WHY WAIT? CSC EXPERIMENTOR sockets are available now from your CSC dealer, or by phone from CSC, at $9.95* for the 300 and $10.95* for the 600. Call 203-624-3103 (East Coast) or 415-421-8872 (West Coast)—major credit cards are accepted.

*Manufacturer's suggested list price. Prices subject to change without notice.
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MARCH 1977 VOLUME 11, NUMBER 3

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

SPECIAL FOCUS ON CB RADIO

COLUMNS

JULIAN HIRSCH AUDIO REPORTS

ELECTRONIC PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

MA BELL STALLS

Last March I happily noted here that the FCC had finally bypassed AT&T and its local telephone companies by permitting end users to install interconnect equipment to Ma Bell's lines without necessarily renting an interconnect modem. The FCC's Docket No. 19528 prescribed a free, simple registration program and technical requirements for making one's own inexpensive interface.

I concluded this column with a farewell to acoustic couplers and an invitation to authors to resubmit those hard-wire telephone projects that we had formerly rejected. Unfortunately, Ma Bell's legal eagles have been running it all through the courts since then, with one challenge after another. Thus far, all court decisions have upheld the FCC decision and its power to make it.

At this writing, though, Bell is before the U.S. Court of Appeals, persisting in its claim that customer-owned equipment must be interfaced only with a device rented from Bell to prevent damage to its lines from faulty equipment. Thus, project builders of equipment that uses telephone lines cannot yet legally bypass renting an interface device with full confidence for the future. This may not be of any consequence to independent suppliers of telephone equipment that connects to Bell's lines or to large businesses, but to electronics hobbyists it means that there is still a monthly rental charge for a dinky little circuit that will cost them, say, $60 per year.

The FCC certification program for privately owned interface devices, which included issuance of an FCC registration number that would be sent by the user to the local telephone company for information purposes only, was wise and long overdue. We all thought, in our innocence, that this capped the 1968 FCC decision that permitted phone equipment to be purchased from suppliers rather than rented from Bell. The FCC observed last year that the Carterfone Decision placed the burden of proof of harm to telephone installations by interconnect equipment upon the carrier, not the users. It's hoped here that the Appeals Court will share this view.

It might seem strange to many people that independent suppliers of telephone equipment can sell phone gear that's more sophisticated than Bell's standard equipment at enormous savings to businesses with, say, six or more telephones.

The free enterprise system is what makes it happen. Bell has to charge businesses more money in order to make up for losses it sustains to support residential service, some of which is very unprofitable. Outside suppliers, on the other hand, don't have to run phone lines to the boondocks; they can focus on a single area and, as they have proved, whip Bell at every turn. Furthermore, the company enjoys a 10 percent tax credit in the purchase year. For these people, the annual connection fee is peanuts.

For the electronics hobbyist, not paying a $60 per year modem rental charge for each device connected to the telephone lines would be a boon to both the hobbyist and Ma Bell. After all, sending and receiving computer data, TV pictures, et al, over the lines would add to Bell's revenue as the minutes tick away. This is phone-line time that would not ordinarily be used.

Of course, AT&T and other telephone companies still have an ace in the hole on all of this. It's called the "Consumer Communications Reform Act," which could overthrow legislatively the FCC rules on interconnecting modems. I hope, however, that this does not come to pass.

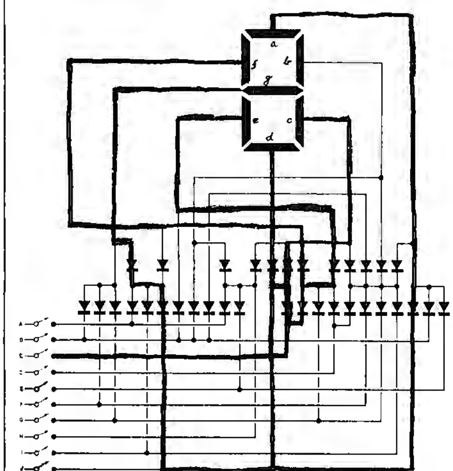
Art Salsberg

CIRCLE NO. 28 ON FREE INFORMATION CARD

Letters

HOW C = 6

I can't get the numeral 6 following the C switch line in January 1977 "LED Circuit Quiz." The only segments I can see that light up are c, d, e, and f. What am I doing wrong?—*Anthony W. Wallace, Portage, IN.*



A number of readers are having the same problem. The correct solution is shown by the accented lines in the drawing.

PIONEER 10 AND TV

In the November 1976 Letters column, J.M. Lagerwerff stated that SECAM 60 color TV equipment was carried on Pioneer 10. Neither Pioneer 10 nor Pioneer 11 carried SECAM 60, PAL, or NTSC TV equipment. The imaging equipment in both cases is called an Imaging Photopolarimeter (IPP), which used separate Bendix Channeltron detectors for the visible red and blue colors. The IPP uses a spin-scan technique of imaging. The spacecraft is spin-stabilized, rotating at approximately 5 rpm, which forms one axis of a two-dimensional scan field. The second axis is formed by stepping a telescope in discrete increments as the spacecraft rotates.

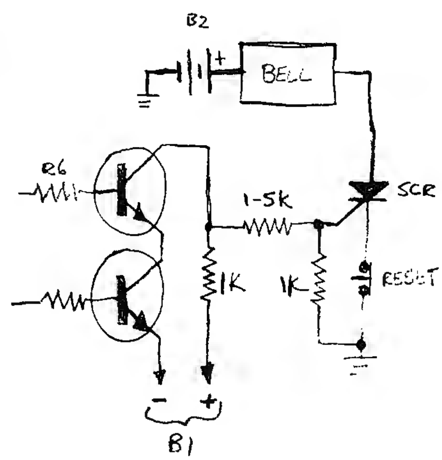
The data from the red and blue channels were encoded to six-bit PCM and transmitted to earth at 1024 bits per second for Pioneer 10 and 2048 bps for Pioneer 11. These rates are far too slow for direct display. Under contract to NASA, I designed, built, and operated the conversion equipment that converted this very slow rate to NTSC color TV, which was then broadcast to the TV networks. The conversion was accomplished with a special slow-scan video disc recorder. Since green is a substantial portion of NTSC color video, I devised a means of synthesizing the green from the red and blue data. Once all three color signals were mixed together, they were fed to an NTSC encoder.

I consider Mr. Lagerwerff's comments on the Pioneer pictures a compliment, as SECAM 60 is a very fine color TV system. —*L. Ralph Baker, Optical Sciences Center, The University of Arizona, Tucson, AZ*

WANTS TO HEAR BELLS

I find that the Sonalert® in my "Low Cost Apartment Burglar Alarm" (July 1976) puts out a sound of insufficient volume. In the article, it was suggested that a higher-power bell or siren could be substituted for the Sonalert. Could you please tell me how to accomplish this? Also, why the connection from the OFF contact of *S1* to the negative side of *B1*, and what is the significance of the −V on the anode side of *D1* and pin 8 of *IC4*?—*S. Possner, Lauderdale Lakes, FL*

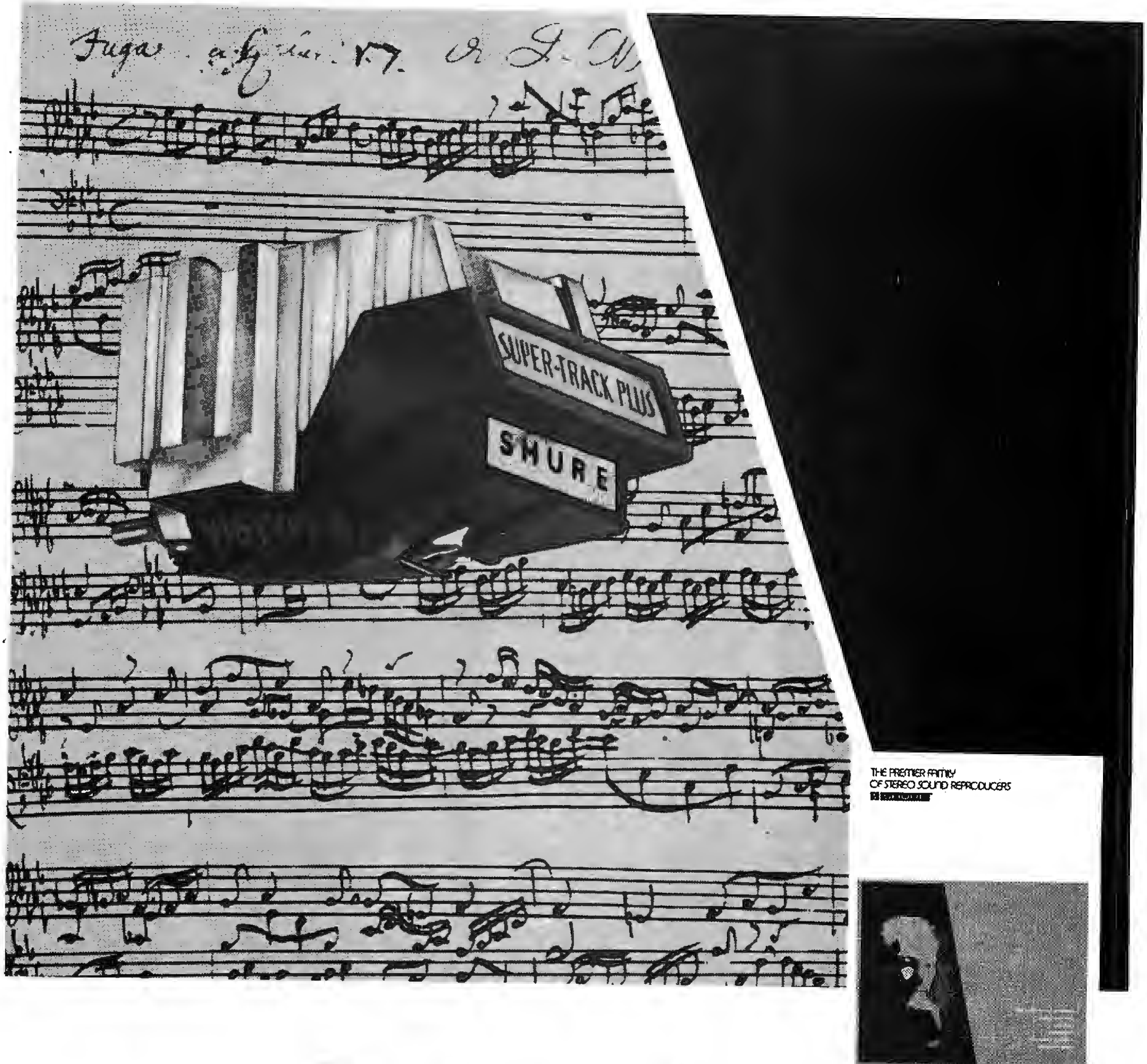
To answer your last two questions first, there should be no connection between B1(−) and S1 (although it makes no difference to circuit operation if this connection is made as shown), and −V at D1 and pin 8 of IC4 means that these two points must be connected together. To add a bell or siren to the circuit, replace the Sonalert with a 1000-ohm resistor and add an SCR control system as shown in the diagram. The value of the



1000-to-5000-ohm resistor will depend on the gate requirements of the SCR selected. You may wish to use a separate high-current battery (B2) for the bell or siren. The RESET switch is required to turn off the SCR in the event the alarm is tripped.

Out of Tune

In "An 'RFI-Free Solid-State Thermostat," January 1977: *R4* in the parts list should be a 2,000-ohm, 1-watt, linear taper, 10% tolerance potentiometer; *R7* in the upper left (connected on one side to the cathode of *D1*) should read *R9*, a 470-ohm resistor. All fixed resistors should be 5% tolerance components.



The Test of Time.

Critics were most generous in their praise when the Shure V-15 Type III phono cartridge was first introduced. The ultimate test, however, has been time. The engineering innovations, the uniform quality and superb performance of the V-15 Type III have made it the audiophile's choice as the source of sound for the finest music systems both here and abroad.

Consider making the relatively modest investment of a new cartridge to upgrade the performance of your entire hi-fi system. It will make a difference you can hear!

The original manuscript by J. S. Bach shown is reproduced by kind permission of the Trustees of The British Museum.

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TECHNICORNER
MODEL V-15 TYPE III
Tracking Force Range: ¾ to 1¼ grams
Frequency Response: 10 to 25,000 Hz
Typical Tracking (in cm/sec peak recorded velocity at 1 gram:)
400 Hz . 26 cm/sec 1,000 Hz . 38 cm/sec
5,000 Hz . 35 cm/sec 10,000 Hz . 26 cm/sec
Channel Separation (Minimum): 25 dB at 1 KHz; 15 dB at 10 KHz
Stylus: Model VN35E Biradial Elliptical, 5 x 18 microns (.0002 x .0007 inches)
Also available: Model V-15 III G with the VN3-G Spherical stylus, 15 microns (.0006 inches)
Model VN78E Biradial Elliptical stylus, 13 x 63 microns (.0005 x .0025 inches) for mono 78 rpm.

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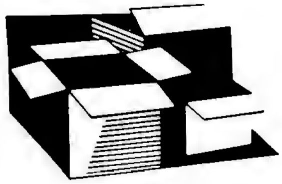
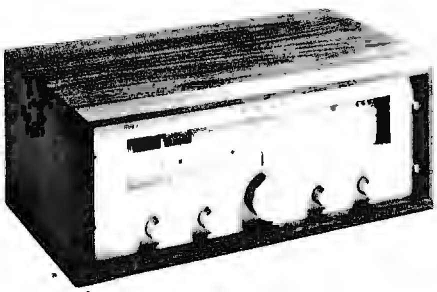


New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

PHASE LINEAR FM TUNER

The Model 5000 is the first FM tuner to be put into the Phase Linear line of separate hi-fi components. The tuner features a built-in dynamic range expander specifically designed for FM to improve dynamic range up to 9 dB.



Lesser amounts of expansion can be selected while receiving those broadcasts that have small amounts of compression. Other features include: fully variable muting; LED multipath indicators; fixed and variable output signal levels; signal-strength and center-channel tuning meters that can be user calibrated; 75/25-μs deemphasis switch; and panel light dimmer. Size is 19"W × 10"D × 7"H (48.3 × 25.4 × 17.8 cm). $499.00.

CIRCLE NO. 91 ON FREE INFORMATION CARD

TELEX CB HEADSET

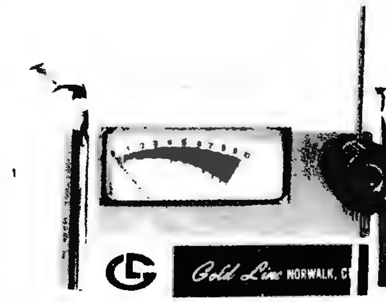
Telex's new lightweight CB headset, the Model CB-88, has a noise-cancelling microphone for clear, crisp voice transmission even where wind, traffic, and engine noise normally interfere with sound quality. The mike has a variable-gain amplifier and is mounted on a pivoting boom. A soft eartip

carries incoming signals directly to the ear. The eartip can be worn in either ear, with or without the headband. An adapter is furnished to allow the earpiece to be clipped to a user's eyeglasses. The push-to-talk switch has a clip for attachment to shirt or blouse. Below $70.

CIRCLE NO 92 ON FREE INFORMATION CARD

GOLD LINE FIELD-STRENGTH METER

The Gold Line Model 1101 is a compact field-strength meter with a frequency range of 20 to 160 MHz, for both base and mobile CB and marine operations. The meter features a



mini-antenna and a multi-color dial designed for easy reading. Measures 2¾"W × 1½"H × 1½"D (7 × 3.8 × 3.8 cm), weighs about half a pound (0.25 kg). $9.95. Address: Gold Line Connector, 25 Van Zant St., East Norwalk, CT 06855.

NATIONAL SC/MP KEYBOARD KIT

The National Semiconductor SC/MP Keyboard Kit is an inexpensive hand-held terminal for use with the 8-bit SC/MP microprocessor kit to eliminate the need for a costly Teletype terminal. It has a 6-digit hex display and features simple μP control to allow the user to evaluate the SC/MP CPU and direct object code program manipulation for development of a variety of applications software. The heart of the kit is a ROM firmware package (512 bytes) that replaces the Kit Bug ROM originally supplied with the SC/MP kit and allows the use of the hex keyboard to modify or examine the contents of memory and the SC/MP registers and to monitor program performance. The kit comes complete with manual, all IC's, resistors, keyboard display cable connector assembly, Wire Wrap connectors, precut wires, and a manual Wire Wrap tool. $95.00.

CIRCLE NO. 93 ON FREE INFORMATION CARD

BOSHEI OPEN-REEL TAPE DECK

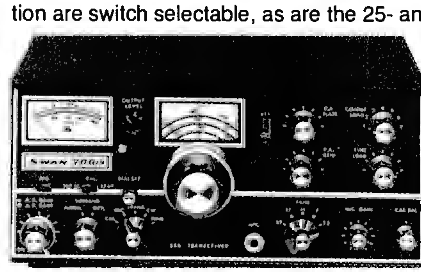
The Model IT-1000 tape deck from Boshei Enterprise Co., USA features four heads, three motors, full-logic solenoid-actuated tape motion, 10" (25.4-cm) reel capacity, and large VU meters. Separate microphone and line inputs and a digital tape counter are also

provided. An Auto Reverse feature provides the convenience of cassettes in an open-reel tape deck, allowing up to 8½ hours of uninterrupted stereo listening. The transport operates at 7½ or 3¾ ips (19.05 or 9.53 cm/s). At 7½ ips, wow and flutter is rated at 0.06% or less, S/N ratio at 55 dB, and frequency response at 30 to 20,000 Hz ±3 dB.

CIRCLE NO. 94 ON FREE INFORMATION CARD

SWAN SSB HAM TRANSCEIVER

A new 700-watt PEP single-sideband Amateur Radio transceiver is now available from Swan Electronics as the Model 700CX. It features up to 10 channels for MARS operation with the optional Model 510-X plug-in crystal-controlled oscillator. Frequency coverage includes the 80-, 40-, 20-, 15-, and 10-meter bands. USB, LSB, and CW modes of operation are switch selectable, as are the 25- and

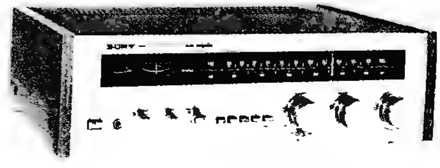


100-kHz calibration frequencies from the built-in calibration oscillator. The audio bandpass is 300 to 3000 Hz. A dual-ratio planetary control scheme is used for the tuning system. The receiver's sensitivity is 0.5 μV at 50 ohms for 10 dB (S + N)/N. Audio output is rated at 4 watts into 3.2 ohms. Size is 13"W × 11"D × 5½"H (33 × 28 × 14 cm) and weight is 17¼ lb (7.8 kg). $649.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

SONY AM/STEREO FM RECEIVER

Sony's Model STR-3800 AM/stereo FM receiver is said to offer a high degree of flexibility in a moderately priced receiver. The amplifier is rated at 25 watts/channel minimum rms into 8 ohms from 20 to 20,000 Hz with no more than 0.5% THD. The tuner section fea-



tures a PLL (phase-locked loop) IC in the multiplex section, FET r-f amplifier, permanently aligned i-f filters. Other ratings include 2-µV IHF sensitivity, 50-dB selectivity, 1.5-dB capture ratio, 68-dB S/N in stereo, and 35-dB stereo separation at 1000 Hz. A stereo indicator, twin tuning meters, and switchable muting are provided. The preamplifer section features a direct-coupled, two-stage phono equalizer for a ±1-dB RIAA tracking and 68 dB S/N ratio. The S/N in the high-level input mode is 90 dB. Size is 19″W × 12⅞″D × 5¾″H (48.2 × 32.7 × 14.6 cm) and weight is 23 lb (10.5 kg). $280.00.

CIRCLE NO. 96 ON FREE INFORMATION CARD

EICO SOLID-STATE ENGINE ANALYZER

Eico's Model 885 Tunemaster solid-state engine analyzer performs up to 16 different automotive tests and analyses. Among them are: ignition points test; dwell test; dwell variation; low rpm (tachometer); high rpm (tach); battery test; accessory current drawn; charging system output; output test (regulator by-

pass); voltage-loss test; ballast resistor test; spark-plug wire test; capacitor test; alternator test; and fuse test. The large 6″ (15.2-cm) meter has multi-range, color-coded scales. Controls include a cylinder selector switch and a mode selector. The tester operates on power from the vehicle's battery. The instruction manual provided with the instrument details step-by-step tune-up information for all domestic and foreign cars. $49.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

MIDLAND 40-CHANNEL CB TRANSCEIVER

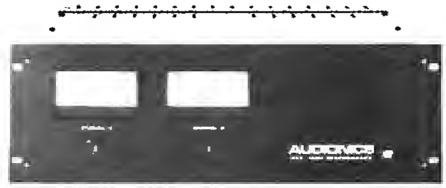
The Midland Model 77-882 40-channel mobile CB transceiver features both switchable automatic noise limiter (anl) and noise blanker, Delta tuning and a variable squelch control. The dual-conversion superheterodyne receiver has a tuned r-f stage, active agc; the transmitter is rated to deliver 4 watts of output power. All-channel operation is obtained with a phase-locked-loop (PLL) synthesizer. Oth-

er features include: a PA switch that delivers 3 watts of audio power, a warning light that indicates antenna mismatch or failure; an S/r-f meter, and an external CB switch that directs received CB signals to an external speaker.

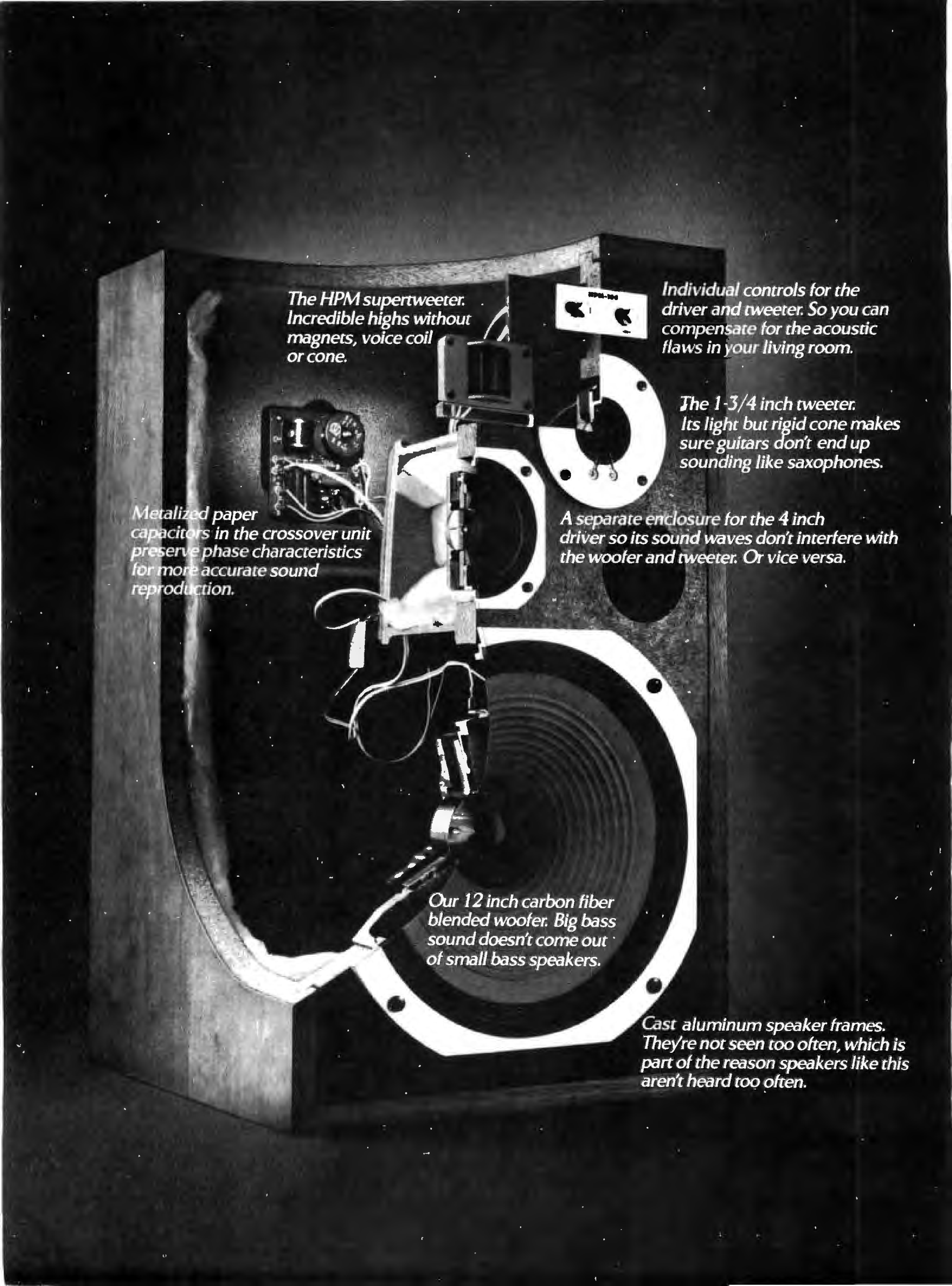
CIRCLE NO. 98 ON FREE INFORMATION CARD

AUDIONICS STEREO POWER AMPLIFIER

The Model PZ3 HP is the second-generation version of the original Audionics Model PZ3 power amplifier. Offered with optional peak-indicating VU meters and input level controls, the new amplifier is rated at 100 watts/channel minimum rms into 8 ohms from 20 to



20,000 Hz at 0.03% maximum THD. Input sensitivity is rated at 1.0 volt for full output. The frequency response at ±0.5 dB is from 20 to 20,000 Hz (5 to 70,000 Hz at −3 dB). Hum and noise are rated at more than 95 dB below the rated output, damping factor at 1000 Hz into 8 ohms is 50, and output impedance is 4 ohms to infinity. The amplifier

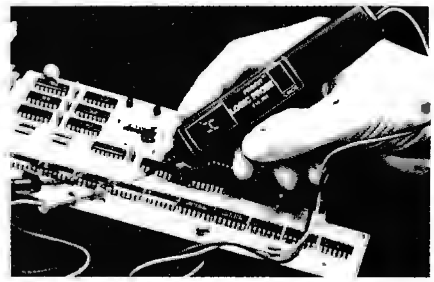

The HPM supertweeter. Incredible highs without magnets, voice coil or cone.
Individual controls for the driver and tweeter. So you can compensate for the acoustic flaws in your living room.
The 1-3/4 inch tweeter. Its light but rigid cone makes sure guitars don't end up sounding like saxophones.
Metalized paper capacitors in the crossover unit preserve phase characteristics for more accurate sound reproduction.
A separate enclosure for the 4 inch driver so its sound waves don't interfere with the woofer and tweeter. Or vice versa.
Our 12 inch carbon fiber blended woofer. Big bass sound doesn't come out of small bass speakers.
Cast aluminum speaker frames. They're not seen too often, which is part of the reason speakers like this aren't heard too often.

comes with a rack-mount front panel with black anodize finish. Size is 19"W × 15"D × 6"H (48.3 × 38.1 × 15.2 cm) and weight is 29 lb (13.2 kg) less meters or 31 lb (14.1 kg) with meters. $429.00 without meters, $529.00 with meters.

CIRCLE NO. 99 ON FREE INFORMATION CARD

DIGITAL LOGIC PROBE

"Probit" is a new digital logic probe from Control & Information Systems, Inc. It tests TTL/DTL and CMOS logic systems and can detect pulses down to 35 ns and accurately check for valid and abnormal logic levels. The probe has greater than 200,000-ohm input impedance (at 30 MHz) to assure minimal loading on the circuit under test. Both over-voltage



and reverse-voltage protection are provided. A seven-segment display indicates "H" for a logic high, "L" for a logic low, and a decimal point for pulse detection. The display is blank for abnormal logic levels. Convenient "Micro-Hooks" are used for test connections, and the probe tip is detachable. The logic family is selected by operating a slide switch on the probe's body. Size is 5"L × 1"Dia. (12.7 × 2.54 cm). $34.95.

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South Shore Trading Corp. has announced a 102" (2.6-m) CB whip antenna that conveniently folds to a compact 15⅝" (39.7 cm) in seconds for easy storage. The SST Whip-A-Way antenna consists of a series of hollow interlocking steel sections that are "strung"

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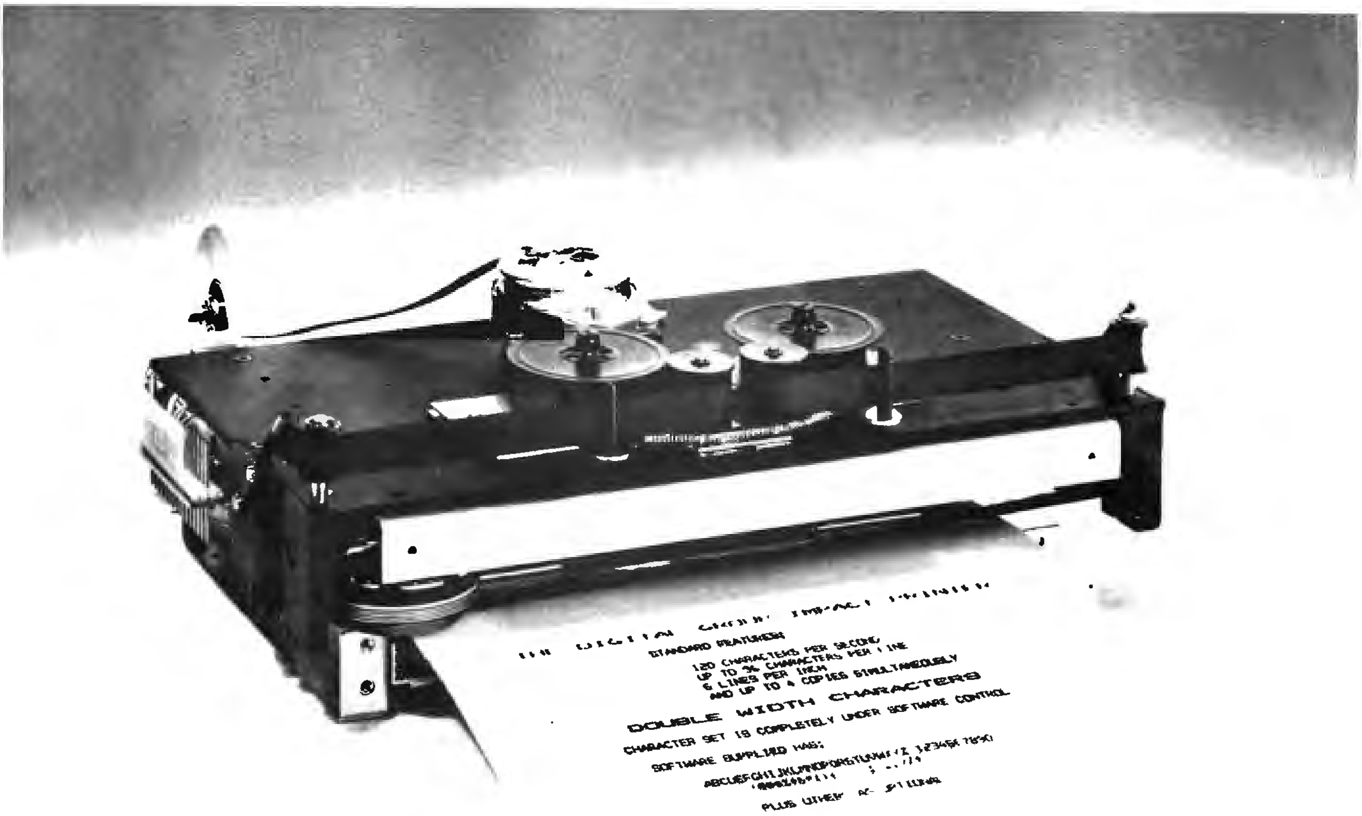

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CIRCLE NO 39 ON FREE INFORMATION CARD

New Literature

ELECTRONIC ORGAN KIT DATA

Devtronix Organ Products is now offering illustrated literature describing different models, related accessories, and simple assembly techniques on its complete line of build-it-yourself electronic organs. Organ types range from small single keyboard practice models to instruments larger than a three-manual theater organ. A 13-minute LP stereo recording, which presents a wide variety of different types of music demonstrating voicing range capability, is also included for 50 cents. Address: Devtronix Organ Products, 5872 Amapola Drive, San Jose, CA 95129.

TOOLS CATALOG

Catalog No. 22 from Techni-Tool is full of unique and often hard-to-find tools for electronics work. Listed are 25 new tool kits for the engineer and technician. The standard lines of hand tools and accessories are listed and illustrated, with more than 10,000 different items. A "Design-A-Kit" section tells the reader how to go about putting together his own tool kit by selecting only those items he needs. Address: Techni-Tool, Inc., Apollo Rd., Plymouth Meeting, PA 19462.

COAXIAL CABLE CATALOG

A new 34-page "Essex Coaxial Cable" catalog is available from Essex Electronic Wire Products. It contains up-to-date listings of coaxial cables, photos, and charts. Sections highlight r-f transmission lines, military RG/U nomenclature, RG/U-type triaxial cable, electronic sub minax coaxial cable, two-way antenna cable, CATV drop lines, etc. Address: Essex Electronic Wire Products, 6235 S. Harlem Ave., Chicago, IL 60638.

SEMICONDUCTOR REPLACEMENT GUIDE

The Workman Electronic Products Semi-Conductor Catalog and Replacement Guide consists of 175 pages that list and cross-reference more than 75,000 manufacturer numbers to more than 200 Workman replacements. It also features a cross-reference to other major semiconductor manufacturers. Address: Workman Electronic Prods., Inc., P.O. Box 3828, Sarasota, FL 33578.

SOUND BROCHURES FROM SHURE

A pair of brochures from Shure describe two products that are said to reduce the complication and cost in finding room response trouble spots in sound systems and to equalize the systems to desired frequency-response curves. Brochures No. AL558 and No. AL554 describe the Model M615AS equalization analyzer system and Model SR107 audio equalizer. Full technical details are given for each product. Address: Shure Bros., Inc., 222 Hartrey Ave., Evanston, IL 60204.

SOUND EQUIPMENT CATALOG

Argos Sound has a new 12-page, three-color catalog with photos and descriptions of its complete line of sound systems and components. Included are a large selection of sound columns, portable sound systems, baffle/speakers, wall baffles, and CB base and mobile speakers. The list of specifications includes weights and measures in the standard and metric systems. Each product is described according to its acoustical application to specific market areas. Address: Argos Sound, 600 S. Sycamore, Genoa, IL 60135.

1802 MICROPROCESSOR USER MANUAL

"User Manual for the RCA CD1802 COSMAC Microprocessor" (No. MPM-201A) is for those with a limited familiarity with computers and programming. It guides the reader through microprocessor architecture and introduces a set of comprehensive, easy-to-use programming instructions. The manual is a detailed guide to the application of the COSMAC CDP1802 microprocessor. Examples illustrate the operation and use of each of the 91 instructions. The manual illustrates methods of adding external memory and control circuits and shows the use of I/O instructions and interface lines, including DMA, interrupts, flags, commands, processor state indicators, and external timing pulses. Price is $5.00. Address: RCA Solid State Div., Box 3200, Somerville, NJ 08876.

CALCULATOR DIGEST

"The Hewlett-Packard Personal Calculator Digest" (32 pages) is written in magazine style and describes the operation and design of hand-held and printing calculators. Subjects include thermal printing, testing, servicing, CMOS, PMOS and NMOS circuits and RPN language. A catalog section provides specification information on each of Hewlett-Packard's calculators, and charts illustrate the uses of each model. Letters to the editor and a question and answer section are also included. Address: Inquiries Manager, Hewlett-Packard Company, 1000 N.E. Circle Blvd., Corvallis, OR 97330.

LOUDSPEAKER CATALOG

"AR Guide to Loudspeakers" is a new, 36-page, full-color catalog, describing Acoustic Research's Advanced Development Division line of speaker systems. It gives detailed information concerning speaker efficiency and placement and amplifier power requirements. The design, production and testing of speakers is explained and a section on the philosophy of music reproduction is included. Price, $1.00. Address: Acoustic Research, 10 American Dr., Norwood, MA 02062 or free from AR products dealers. A dealer list will be sent on request.

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Stereo Scene

BY RALPH HODGES

THE HOUSE THAT HI-FI BUILT

"Live music is the only standard," we are told. "Your audio system may sound impressive, but does it sound like the real thing?" "Go to a concert before you pick out your speaker systems." And occasionally, when our judgment in matters of sonic accuracy is being called into question: "When was the last time you listened to live music?"

Well, the definition of high fidelity implies faithfulness to something; isn't live music a perfectly natural and appropriate something? Surely. But as one who hears live music several times a week at the very least, I have a particular problem with this proposition: I can't for the life of me figure out what *live* music sounds like.

It may seem like an heretical statement, but I would hardly call a season ticket to Boston's Symphony Hall (or any other auditorium) an adequate acquaintance with the sound of live music. As proud Bostonians must be aware, the experience of hearing music in Symphony Hall is unique, and usually very rewarding. The same music heard elsewhere sounds different. In fact, of the various recordings I have that were made in this hall, there is none that does more than stir the vaguest recollections of the live experience. Perhaps this is because the recording team didn't trouble to cluster the microphones around my usual seat. (Indeed, if former practice still prevails, my usual seat is actually ripped out of the hall for recording sessions, and part of the orchestra put in its place.) But whatever the reason, the fact remains that music in Symphony Hall does not sound very much like music in, say, New York's Carnegie Hall.

Avery Fisher Hall. Certainly music in Boston's Symphony Hall sounds different than it did in New York's old Philharmonic Hall—so different that New York concert-goers were up in arms about it for years. If you've read a newspaper since 1974, you probably know that that unfortunate situation has largely been rectified. A little over two years ago the retiring Avery Fisher, founder of Fisher Radio (which once advertised high-fidelity systems as the means to acquaint your children with the live music they might otherwise never hear), settled a handsome sum on the Lincoln Center corporation, which used the funds to totally rebuild the auditorium (duly renamed Avery Fisher Hall) from the inside out. It was truly the house that hi-fi (or hi-fi money, anyway) built. First critical reaction to the new structure was generally approving, which strongly whetted the appetites of myself and other likeminded souls to hear this wonder. However, I decided to put off my initial visit for several months to allow the orchestra time to accommodate itself to the new environment. When I did make my move, just a few days ago, it was with the most helpful cooperation of the N.Y. Philharmonic press office, which got me admitted to the morning rehearsal for a large-scale concert, and to the first performance that evening. The program (Saint-Saens' Third Symphony and Shostakovich's Fourteenth) probably could not have been improved upon for my purposes, involving as it did the full Romantic symphony orchestra, organ (electric organ; the hall's pipe instrument went with the renovation), piano, solo voices, and the full dynamic range of which all these instruments are capable. Leonard Bernstein conducted.

New York's new Avery Fisher Hall.

Different Seat, Different Sound. When I walked into the rehearsal, I learned that only the three upper tiers in the back of the hall were available for seating. The orchestra floor was verboten, and the side boxes were still being worked on. From the approximate front center of the first (lowest)tier, the sound of the orchestra tuning up was encouraging. Everything seemed to project, particularly the low strings, which were elusive in the old hall. But then as Bernstein, with his left side to our small audience of freeloaders, conferred for several minutes with the organist, I noted that the sibilance in his voice was all but inaudible, although the body of the speech was there.

This impression—a lack of brilliance—persisted as the music began. The low strings remained robust, but the violin choruses seemed muffled, diffuse, and somewhat wavery and unsteady in their texture. It was a most familiar effect; I have heard it and cursed it on many now-discarded "high-fidelity" systems. Was I too hasty in blaming the equipment?

Another problem: the sound was weak. On the vigorous tutti in the early minutes of the Saint-Saens my little sound-level meter (which was creating a minor sensation amongst my neighbors) showed a maximum of 94 dB (unweighted). Average level was perhaps 88 dB, which I think is too soft, especially with the hall largely unoccupied by a sound-absorbing audience. Astonishingly, the brass parts could scarcely be distinguished from the overall texture, the sound was so lacking in edge and "bite."

Curious about the effect of the overhanging tier on reflections from the ceiling, I then moved to the left rear corner of the first tier. The sound underwent a remarkable transformation. I'm not sure I can explain it, but I can describe it perfectly: it was the sound of a dirty stylus, without question. And mind you, this is live music!

The Second Tier. Up one story, and again front and center, there was an appreciable improvement. Now some sibilance was detectable in Bernstein's

voice, even with his back turned. The violins began to coalesce more, and the quality of their attack was more apparent. Brass was still a disappointment, however, sounding wooly and indistinct.

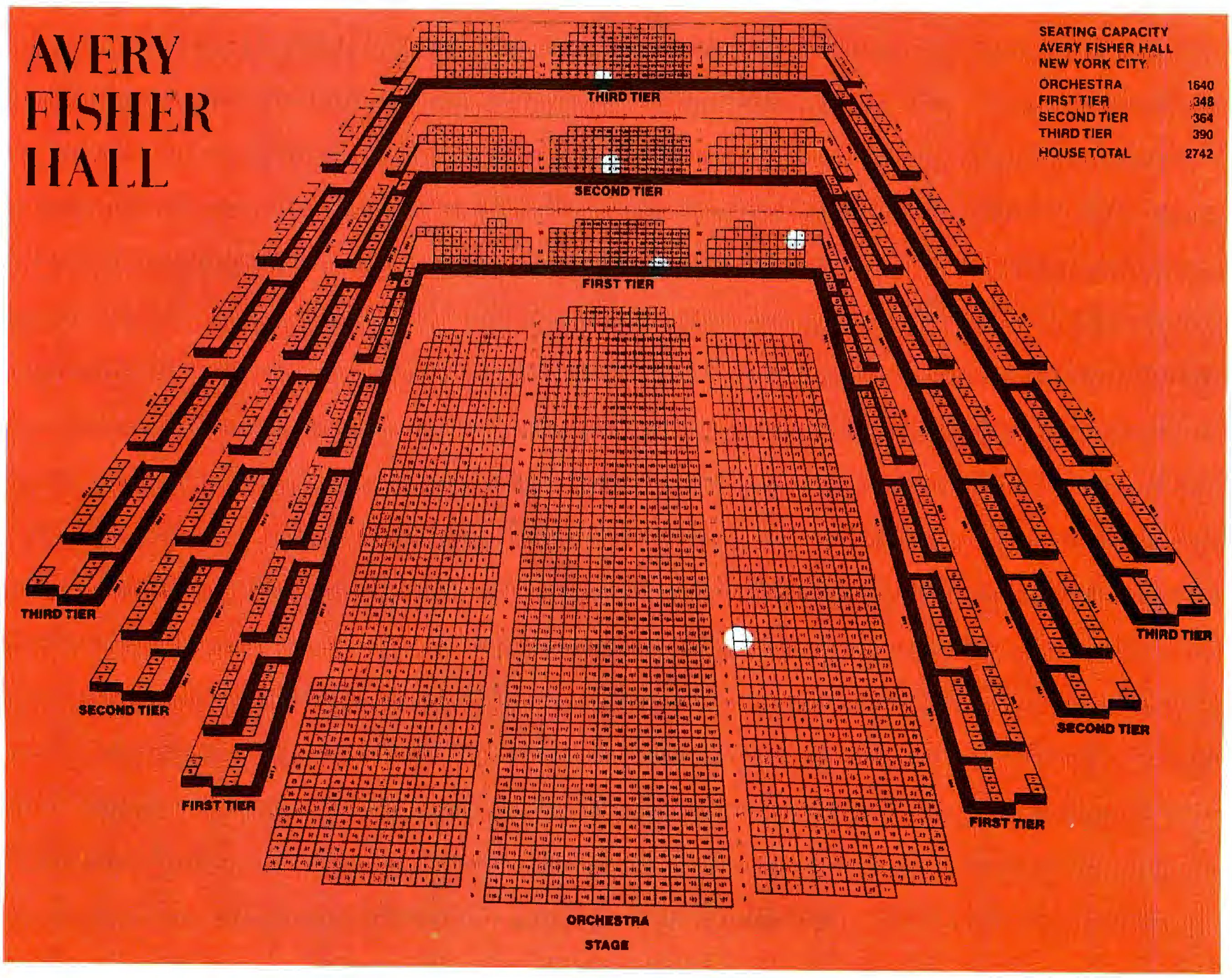
It was here that I measured the hyperactive finale of the Saint-Saens, which got up to 98 dB (96 dB without the bass drum, which didn't sound like much, but which certainly rocked the meter). This is not enough, particularly if the sound is not radiantly alive to begin with. But feeling I was on the track of something, I made my solitary way up to the cheap seats in. . . .

The Third Tier. I was really not prepared for what I heard. The orchestra by now was well into the Shostakovich, and the cellos and basses were executing a quiet passage in pizzicato and short, light bowing as I sat down. A fat, rich, glorious "Thrummm" resounded throughout the hall below. When the high strings entered they rushed into focus, bright, full-bodied, precise in attack, and sometimes even a little steely, although never harsh. The soprano voice, which before had struggled to emerge above the orchestra (incidentally, the soprano and bass were on risers behind the string orchestra, presumably to benefit from the horn-like flare of the stage enclosure), had power that seemed to saturate the stage area and swell irresistably out. And the important xylophone part had a quality—a stinging, violent snap—that I would have sworn could be captured only by closely spaced microphones, as in the recording I had listened to the night before.

As you can tell, I loved it all. The sound had precisely those characteristics—power, clarity, brilliance, attack—that I look for in a reproducing system and in a recording. Paradoxically, these effects were available (in the seats open to me) only in the part of the hall most remote from the stage. But the explanation, I think, is simple. The third tier also offers the seats closest to the ceiling, which is probably the major sound-reflecting structure in the hall. This proximity means that a host of reflections arrive almost immediately to reinforce the direct sound reaching you. I only wish the brass had been present (they retired after the Saint-Saens) to cap the whole thing. I made no measurements in the third tier just because the orchestra was so diminished in size and power.

The Performance. The seats we were assigned for the evening performance were to the left of the orchestra section, row U—significantly remote from my listening sites of the morning, which was too bad. Throughout the day I had wondered whether the acoustic absorption of an audience might diminish the prominent mid-range and upper bass, exposing the brilliance I wanted to hear. I have the impression that it helped, but I lacked a standard of comparison and couldn't judge reliably.

In row U-left, it was possible to sense the contributions of both the direct sound from the orchestra and the reflec-



During rehearsal, the author sat in the first tier, row AA, seat 104 (shown by circle in color overlay); then first tier, DD-19; second tier, BB-109; third tier, AA-110. For the performance, orchestra, U-1.

tions from the hall for many instruments. For other instruments (the violins, for example) reflected sound dominated; the string basses, hard by the stage's right reflecting wall, provided almost all direct sound and early reflections, which made them sound very taut, damped, and strangely woody.

Being much closer to the orchestra helped enormously in terms of loudness, and the climaxes were quite satisfying. However, the violins, although clear, were oddly disembodied and somewhat dim, giving a slight cotton-in-the-ears feeling that either they weren't completely there, or you weren't. Woodwind detail was good, with credible timbre, but the brass, quite audible at last, still lacked that characteristic "buzzy" edge of excitement. The brass also seemed late and unsure in its attacks—apparently a result of the time necessary for the sound to build up in the hall. The pedal notes from the organ (extreme stage left, with speakers aiming roughly into the stage enclosure) were not as prominent as they had been in the tiers. And the soprano voice was again struggling to rise above the orchestra.

Having said all this, I'll add that the overall performance, executed as well as I could ever hope to hear for both pieces, was tremendously dramatic, arresting, and satisfying. It did not, however, sound very much like my idea of live music!

Semi-live. At one time or another, I think I have heard—at live performances in real concert halls and elsewhere—virtually all the faults I've ever heard in subpar high-fidelity systems. The catalogue includes harsh, strident violins, boomy bass, overall fuzziness or raspiness, poor transient response, bad stereo, honkiness, nasality, and even ripping and rattling noises suggestive of cartridge mistracking (usually coming from the bowed strings). When you consider the usual causes for these "distortions" in real and reproduced music, you'll see that they are often somewhat analogous, so I guess it's not too surprising that they sound much the same.

Still, live music does have a definable sound: the sound of the instruments without any interfering acoustic. For lack of a better substitute, this is what I generally use. The accomplished street violinist who prowls Manhattan's Fifth Avenue is my reference for string sound. Brass I get from several talented quintets who set up at the entrance to New York City's Central Park Zoo in the summers. Woodwinds—flutes, oboes, clarinets, and even bassoons and bass clarinets—abound throughout the city, as do jazz "combos" with abilities and instruments of widely varying quality. There is even a touring bagpipe, for those so inclined.

This is open-air music, without any enveloping acoustic. When you have a good sense of the instrument itself, I believe you're better prepared to make allowances for its sound in different settings, concert halls and listening rooms included. But as for the usual sound of "live" music, it has a variety of sounds; a good reproducing system will reveal this variety, rather than some hypothetical sameness.

P.S. Should the above remarks seem to reflect unfavorably on Fisher Hall, I take them all back. It, too, in its way is an instrument, and a rather sophisticated one. But avoid those rear corners. ◇

(Photos by Susanne Faulkner Stevens.)

View from the stage of the 2742-seat auditorium in the newly reconstructed Avery Fisher Hall at Lincoln Center for the Performing Arts, New York. Seating plan opposite.

Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

MEASURING AND INTERPRETING TURNTABLE RUMBLE

ONE OF the key specifications of a phonograph turntable is its *rumble* level. Rumble is the audible result of mechanical vibration that causes the pickup cartridge to move relative to the record, or vice versa. This produces an electrical output signal that cannot be distinguished from the recorded program, at a very low audio or sub-audible frequency. As the name suggests, the sound often resembles a low-pitched hum. The vibration comes principally from the motor, although other rotating parts (such as an idler wheel) can also contribute.

In general, rumble covers a broad spectrum of frequencies, with some emphasis on certain discrete frequencies. For example, a conventional four-pole motor, operating from a 60-Hz power line, revolves at about 1800 rpm, or 30 revolutions per second. A slight unbalance or eccentricity in the rotor or its shaft will cause the motor to vibrate at 30 Hz. If the vibration is allowed to reach the platter or the pickup arm, it will generate a 30-Hz signal in the cartridge outputs. Usually this is accompanied by higher frequency components, generally at harmonics of the basic revolution frequency (in this case, 60 Hz, 90 Hz, etc.). The idler wheel turns more slowly than the motor, but is more likely to be eccentric and thus contributes a number of rumble vibration frequencies, beginning at a few hertz and overlapping the range of frequencies contributed by the motor. Finally, the platter itself, turning at 33⅓ rpm, has a basic rumble frequency of about 0.5 Hz, with harmonics extending into the idler-wheel range.

The result is a broad band of nearly random vibration, covering the frequency range from 0.5 Hz to perhaps 100 Hz or higher, with certain frequencies being emphasized. A major source of this emphasis is the resonance of the tonearm mass with the stylus compliance, which usually lies between 5 and 10 Hz. At this frequency, the rumble output is often boosted by 5 to 10 dB. Belt-drive turntables, of course, do not have the rumble of an idler wheel to contend with, and the flexible belt filters out some of the motor vibration before it can reach the platter. Their rumble content thus tends to be concentrated at the motor frequency and its harmonics, and is often at a lower level than the total rumble of an idler-driven turntable (although there are numerous exceptions).

In recent years, direct-drive turntables have become quite popular. Since only one revolving element is involved (the platter and motor rotor, acting as a unit), one would expect its rumble to be limited to the basic 0.5-Hz rate, with some harmonics of that frequency. However, direct-drive motors have a number of discrete poles, causing their driving torque to pulsate slightly at a frequency much higher than the basic revolution rate. Depending on their design, they may have low-level rumble components at frequencies of 10, 20, or even 40 Hz.

Rumble is measured by playing a "silent groove" record and measuring the cartridge output voltage, through a preamplifier having standard RIAA equalization. The reference level is usually the cartridge output from a lateral (mono) recording at a velocity of 5 cm/s at 1000 Hz, although some measurement standards are based on 7 or 10 cm/s reference velocities, giving an *apparent* rumble improvement of 3 or 6 dB, respectively (rumble is expressed in decibels below the reference level).

Because of the greatly reduced sensitivity of the human ear at low frequencies, the audibility of rumble is very much a function of its frequency distribution. A −30-dB rumble at 60 or 90 Hz, for example, would be disturbing under almost any listening condition, whereas the same level at 30 Hz might not be audible, and at 10 Hz it certainly could not be heard. To account for this phenomenon, it is usual to *weight* a rumble measurement by placing a high-pass filter between the preamplifier output and the indicating meter.

Several different weighting curves are in use throughout the world. The DIN "B" characteristic is widely used in Europe and Japan, while in this country the CBS Audible Rumble Loudness Level (ARLL) weighting is often employed (we use ARLL weighting in our turntable tests). The same turntable, measured with different weighting curves, will appear to have very different rumble ratings, and it is not possible to convert a reading from one system to another. In general, the DIN "B" curve will give a lower apparent rumble reading than the ARLL curve, and will be 20 to 30 dB lower than an unweighted measurement. Either system, as well as several others that have been proposed and are in use, can be justified empirically by listening tests. Fortunately for the consumer, it is not the absolute numerical value of rumble that is important; so long as the same system is used, comparisons can be made between turntables without serious loss of accuracy.

Unweighted rumble readings (or the DIN "A" mea-

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surement, which is very similar) also provide useful information. Rumble at sub-audible frequencies may not be heard directly, but can seriously degrade sound quality if it is strong enough. If the amplifier has extended low-bass response (down to a few Hz or to dc) these rumble frequencies can overload the amplifier or move the speaker cones beyond their linear range. The result is a muddying of the sound, caused by intermodulation distortion. This effect can be seen easily by removing the speaker grille cloth and observing the woofer cone while playing a record at a fairly high volume. The sub-sonic "bobbling" of the cone is a clear indication of rumble, even if it cannot be heard. Do not confuse this with the 0.5-Hz in-and-out motion of the cone caused by record eccentricity or warping. Although this can produce the same effect, it is not the fault of the turntable.

It is difficult to state categorically how much rumble is "acceptable." This is a function of room and speaker characteristics, listening volume, and personal opinion. In general, a turntable with an unweighted rumble level of −30 dB or better, and a weighted rumble level below −50 dB, will not contribute significant audible rumble to the program (many records have inherent low-frequency noise that will mask turntable rumble below these levels). If your records are good, and the speakers have a useful response down to 30 or 40 Hz, it might be advisable to look for a turntable with an unweighted rumble of −35 dB or less, and a weighted rumble (ARLL) of −50 to −60 dB, which is typical of some of the better belt-drive players and most direct-drive turntables. Still lower rumble levels can be had, at a price, but do not expect to hear the difference.

About This Month's Reports.

In contrast to recent trends toward technical sophistication in record players, Empire's new Model 698 might be considered as a modern classic. Its only concession to such competitive pressures is an electronically actuated cueing system, which also lifts the arm at the end of a record. Otherwise, it is based on the proven, reliable belt-drive system that has been used in previous Empire players with eminent success. A heavy, finely machined platter, driven by a carefully balanced synchronous motor, results in rumble and flutter levels comparable to, and in some cases lower than, those achieved by much more elaborate means. As always, simplicity is a virtue, and nothing could be more simple and direct than the Empire approach. The major improvement in the 698, compared to previous Empire models, is the drastically reduced arm mass which makes it compatible with today's high compliance cartridges.

Not everyone needs, or can afford, one of the "super power" stereo receivers offered by several manufacturers. The Sherwood S-7910 has most of the operating features, to say nothing of advanced performance, of much more costly products. Its conservative 60 watts per channel is more than sufficient for the majority of home listening requirements. Its FM tuner section is especially noteworthy. Among other assets, it has the greatest stereo channel separation we have yet measured on a tuner or receiver, and a tuning indicator light that glows brightly when the tuner is accurately centered on the station frequency (there are two meters, as well, for those who prefer to use them, but the light is faster and easier to use and at least as effective).

EMPIRE MODEL 698 RECORD PLAYER

Aesthetically pleasing, precisely constructed manual turntable.

HIRSCH-HOUCK LABS REPORT

Empire Scientific has long been known for its distinctively styled manual record players. The latest version, the Model 698, looks very much like its predecessors, but it has been given a new low-mass tonearm and an electronically controlled cueing lift system. The player's turntable is basically unchanged from earlier models. It employs a heavy-duty hysteresis synchronous motor and belt-drive system that offers the user a choice of 33⅓ and 45 rpm speeds.

All visible metal parts of the record player, including the motorboard, platter, and tonearm, are handsomely finished in satin gold. This is complemented by a wooden walnut base and a walnut and clear-plastic hinged dust cover that remains open at any angle. The record player measures 17½" W × 15⅛" D × 8 3/16" H (44.5 × 38.4 × 20.8 cm) and weighs slightly less than 30 lb (13.5 kg). The market value of the player, less cartridge, is $400.

General Description. The turntable platter features two-piece construction. Its massive central disc is almost 3" (7.6 cm) thick and is coupled to the motor by a precision-ground belt. A larger-diameter ring-like platter that contains the ribbed record mat fits over the central disc. This ring also contains the stroboscope markings. The total weight of the platter system is more than 7 lb (3.2 kg). Although the operating speeds are basically fixed (changed by removing a cover retained by a thumbscrew and manually shifting the belt to a different pulley on the motor shaft), a small change in speed is possible by slight adjustment of a screw that tilts the motor's axis.

The tonearm measures 9" (22.9 cm) from pivot to stylus. It has a newly designed cartridge shell that is easily detached for cartridge installation. The mass of the shell is claimed to be comparable to the mass of fixed shells, accomplished through extensive slotting to remove material. The design of the shell permits adjustment of the cartridge's position for correct overhang. The counterweight, which slides on the rear of the tonearm's tube for balancing, is decoupled by an elastic bushing to damp out the low-frequency resonance.

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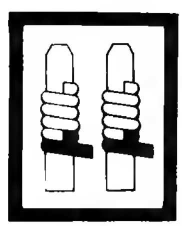

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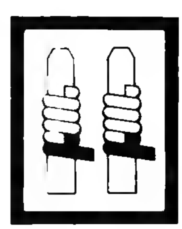

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The vertical tracking force is applied to the balanced tonearm by a calibrated clock spring that is wound around the vertical pivot. It is adjusted by a knurled wheel on the pivot structure. Calibrations are from 0 to 4 grams at 0.5-gram intervals. A dial on top of the pivot housing is for adjusting the antiskating force.

The cueing mechanism is operated by a damped dc solenoid whose motion is initiated by a mere touch of the finger on one of two pairs of closely spaced contacts on the motorboard. No pressure is necessary; the bridging of a pair of contacts by the finger triggers electronic circuits that energize the cueing mechanism. A red light behind each pair of contacts indicates the status of the arm-lifting mechanism, either up or down. At the end of play, a beam of light shining on the photocell under the motorboard is interrupted by a vane that moves with the tonearm. This causes the tonearm to automatically raise from the record's surface. It does not return to its rest post. The arm must be returned and the motor must be shut off manually. A rocker switch controls all power to the record player.

As with earlier Empire record players, the tonearm and turntable of the Model 698 are rigidly mounted to a Y-shaped ribbed casting and the entire system is resiliently floated from the motorboard. This isolates the tonearm and turntable from motor vibration as well as from external shock and vibration. The motor is, in turn, suspended on rubber bushings from the motorboard. A socket under the tonearm receives one of the two plug-in signal cables supplied with the record player. For stereo operation, the longer 5′ (1.5-m) cable is used. This cable has a nominal capacitance to ground of 180 pF/channel, which, combined with the input capacitance of a typical preamplifier, will load the phono cartridge with approximately 250 pF of capacitance. If a CD-4 cartridge is used, the 4′ (1.2-m) cable, whose nominal capacitance is 70 pF for a recommended 100-pF maximum capacitance for CD-4 cartridges, is used.

Laboratory Measurements. We tested the record player with Empire's top-of-the line Model 2000Z phono cartridge installed in the tonearm shell. After we balanced the tonearm in the horizontal plane according to instructions, the actual vertical force was about 15% less than the dial indication. We then adjusted the counterweight to correct the error, which yielded exact agreement with the calibrations over the full range of the dial. We noted, however, that at the zero setting, the pickup stylus rested in the plane of the record, well below the horizontal.

We adjusted the overhang by aligning the stylus with the end of the cartridge shell as detailed in the instructions. This is an uncertain procedure because of the considerable distance between the stylus and the reference line, which almost inevitably leads to parallax error. However, when we made the adjustment carefully, the tracking error was extremely low, measuring zero at 3″ and 5″ radii and less than 0.4°/in. between 2.5″ and 6″. The antiskating force had to be set slightly higher than indicated by the tracking force setting, to 2 grams at a 1-gram tracking force, for equal tracking effectiveness on both channels of a 30-cm/s, 1000-Hz test record. Since less compensation will be required at lower velocities, we consider the antiskating calibration to be sufficiently accurate for its purpose.

The lift and descent of the cueing mechanism were both slow and well damped, with little tendency for the pickup to drift outward during descent. About three seconds were required for the tonearm to lift or descend completely once movement began. However, there was an appreciable delay between the time the contacts were touched and the time the tonearm began to move.

The measured capacitance of the two signal cables, including the wiring in the tonearm, was 175 and 85 pF. Because of the action of the elastically mounted counterweight, the resonance of the tonearm with the Model 2000Z cartridge installed exhibited two small peaks. One was at 5.5 Hz and the larger, at 8 Hz, had an amplitude of about 6 dB.

The operating speeds were exact and did not detectably vary with line changes from 95 to 135 volts. The combined unweighted rms wow and flutter was 0.04%. The weighted rms flutter of 0.03% was about as low as we have ever measured and is quite possibly at the residual level of the test records we used. The unweighted lateral rumble was −36 dB, which improved to −57 dB with ARLL weighting.

When we vibrated the entire record player through its mounting feet (which are rigidly attached to the wooden base), it displayed average isolation of the pickup system from external vibration.

User Comment. In contrast to the almost "ready-to-play" condition of some record players as they are unpacked, the Empire Model 698 must be largely assembled by the user. In particular, the tonearm must be mounted and carefully adjusted for height and horizontal orientation (in order for the automatic end-of-play arm lift to operate correctly). This is not difficult, especially since the instructions are complete and clearly written, but it is no job for a neophyte, either. As we have noted, the tonearm should be balanced somewhat below the horizontal with cartridge overhang adjusted with the greatest care to avoid parallax errors.

We found the visibility of the tracking force dial calibrations to be rather poor because of their location on the rear "inside" portion of the pivot support, but this is only a one-time per cartridge adjustment. If you are accustomed to "splitting grams" in setting up a cartridge, the 0.5-gram calibration intervals may seem wide. Fortunately, few cartridges must be set up closer than 0.25 grams from an optimum force, which can be easily interpolated from the dial scale.

When it is properly set up, the Model 698 is one of the most aesthetically pleasing, precisely constructed record players obtainable. Records must be played manually, since the mechanism does nothing automatically except to raise and lower the tonearm (and the long wait for the arm cueing system to go into action tends to discourage its use). As far as "specifications" are concerned, the record player clearly excels in its low flutter. If lower flutter figures are possible, we doubt they could be measured with commercially available test records.

Our measurements show rumble to be about as good as any belt-driven turntable we have seen and nearly equal to the better direct-drive units. The ARLL weighted figure of −57 dB represents essentially inaudible rumble, which will be masked by the rumble and low-frequency noise inherent in most records.

A spectrum analysis of the rumble output shows a major component at about 8 Hz (tonearm resonance) and a single, almost discrete component at about 30 Hz (motor revolution frequency). Note that the RIAA equalization which we use, and which is part of the ARLL weighting, boosts the 30-Hz level by about 18 dB.

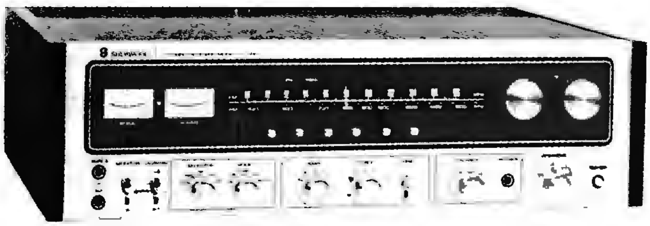
Should the record player be located in an area that causes excessive physical vibration from, say, poor flooring, to reach the system, we recommend installing acoustic isolation mounts. These are available from Audio-Technica

(AT-605 Audio Insulator) and Netronics ("Acoustic-Mount").

In sum, the Empire Model 698 is a beautifully constructed and finished product, one of the few remaining truly manual record players. It should be able to extract the fullest measure of performance from any cartridge and record. It is certain, too, that no one will wish to hide it from view since it is one audio product that looks as good as it sounds.

SHERWOOD MODEL S-7910 STEREO RECEIVER

Top performer in upper-medium price class.



HIRSCH-HOUCK LABS REPORT

The full-featured Model S-7910 is just one notch removed from the top of the Sherwood line of stereo receivers. It is rated to deliver at least 60 watts/channel into 8-ohm loads between 20 and 20,000 Hz with less than 0.1% total harmonic distortion (THD).

This receiver has several interesting features. Its 4 CH ADAPTER facility duplicates the functions of a tape-monitoring circuit, which makes it possible to connect a total of three tape decks into the system. This adapter circuit is isolated to prevent interaction with the two main tape circuits. Located before the VOLUME, BALANCE, and tone controls, this facility appears to be an ideal place to connect a Dolby decoder for FM reception, although the user manual makes no mention of this. The FM tuner has linear-phase ceramic i-f filters, PLL (phase-locked-loop) multiplex demodulator, and a Sherwood-developed "digital detector" that never requires alignment and is inherently highly linear and immune to amplitude-modulated signals and noise. The digital detector appears to be a pulse counter detector, judging from the limited information supplied. The three-stage phono preamplifier employs a differential amplifier as its input stage.

The receiver measures 24½"W × 15 ⅝"D × 5⅞"H (54 × 40 × 15 cm) and weighs 34 lb (15.5 kg). Supplied with a walnut-veneered cabinet, it is available in AM/stereo FM and FM-only versions as the Models S-7910 and S-8910 for $500 and $475, respectively.

General Description. The receiver is handsomely styled, with the upper half of the front panel devoted to the dial scales, tuning meters, and the large VOLUME and TUNING knobs. Just below the dial scales are six small pushbutton switches that can be used to change the FM deemphasis from 75 to 25 μs for use with an external Dolby noise-reduction system, engage and disengage the FM muting, allow the receiver to respond to only stereo FM broadcasts, insert an external 4-channel adapter into the signal path, and switch in and out the loudness-compensation circuit.

Illuminated legends appear above the blue dial scales in red to indicate the selected input and when a stereo FM broadcast is being received. Between the signal-strength and FM center-channel meters is a red LED (Sherwood's "Positune" feature) that glows when an FM signal is properly tuned.

The control panel is finished in satin gold, and related groups of controls are enclosed with thin black lines. The SELECTOR switch has positions for PHONO 1, PHONO 2, FM, AM, and AUX inputs. The MODE switch permits selection of either the left or the right channel inputs through both outputs, normal and reversed stereo, and mono (L + R) operation.

The BASS and TREBLE controls are both detented at 11 positions. A lever switch is provided for bypassing the tone controls entirely. To the right of the tone controls are the BALANCE control and a stereo headphone jack. At the far right of the control panel is the SPEAKERS switching arrangement, which activates either, both, or neither of two pairs of speaker outputs. If the second pair of speaker systems is located in the rear of the listening room, the ARS (Ambience Retreival System) position of the SPEAKERS switch connects them in an ambience-recovery configuration to simulate 4-channel sound from 2-channel sources. The pushbutton POWER switch is located near the SPEAKERS switch.

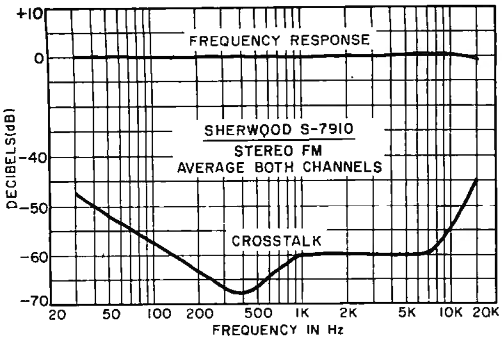
At the lower left of the panel are the tape-monitoring and tape-recording controls. The MONITOR lever switch can be used to connect the receiver's amplifiers to the playback from either of two tape decks or to the selected program source. A similar DUBBING switch interconnects the two tape decks for copying tapes from either one to the other—without interrupting listening to the selected program. Two stereo phone jacks on the front panel parallel the TAPE 2 inputs and outputs on the rear apron for convenience in taping with a recorder that is not permanently connected into the system.

On the rear apron, the various input and output jacks are supplemented by separate PRE OUT and MAIN IN jacks that are connected together in normal operation with a slide switch. Setting the switch to its alternate position opens the signal path for separate access to the outputs of the preamplifier and inputs of the main-amplifier sections so that an active crossover network or other accessory can be inserted into the system. A DIN socket duplicates the functions of the TAPE 2 circuits.

A slide switch near the PHONO 2 jacks provides a choice of three sensitivities to accommodate phono cartridges that have widely differing output signal levels. (The PHONO 1 sensitivity is the same as the highest sensitivity of the PHONO 2 input.) Spring-loaded speaker terminals eliminate the possibility of shorted wires because they require insertion of the stripped wire into small holes in the connector. In addition to the 75- and 300-ohm FM antenna terminals and a terminal for a wire-type AM antenna, there is a hinged and pivoted AM ferrite-rod antenna. There are three accessory ac outlets, two of which are switched.

The output transistors of the amplifier section and the speakers are protected against damage by a fast-acting relay that also provides a turn-on time delay of several seconds. The transistors and their heat sinks are located entirely within the receiver, just inside the rear apron.

Laboratory Measurements. Following the usual one-hour precondition-



Frequency response and crosstalk averged for both channels in stereo FM.

ing period at one-third rated power, the receiver's rear apron was quite warm, but its top was only mildly warm. The outputs clipped at 74.4 watts/channel into 8 ohms, with both channels driven at 1000 Hz. The 4- and 16-ohm outputs were 97 and 46.6 watts, respectively.

The total harmonic distortion (THD) of the audio amplifiers was very low. It was a barely measurable 0.005% at 0.1 watt and less than 0.01% up to 17 watts output. It was only 0.022% at the rated 60 watts and 0.13% at the clipping output of approximately 75 watts. The intermodulation distortion (IM) was between 0.022% and 0.033% from 0.1 to 20 watts, 0.067% at the rated 60 watts, and 0.1% at 75 watts. At rated output, the THD was between 0.02% and 0.03% from 20 to 7000 Hz. It increased to 0.071% at 20,000 Hz. At lower power outputs, the THD was less at all frequencies, being typically about 0.01% at usable frequencies and power levels.

The amplifier required an AUX input of 66 mV to develop a reference output of 10 watts, with a S/N ratio of 75.5 dB. The PHONO 2 sensitivity was 0.76, 1.5, or 3.3 mV for a 10-watt output, depending on the setting of the sensitivity switch on the rear apron. It was 0.76 mV through PHONO 1. The phono S/N ratio was 72.6 dB, and the phono overload points were unusually high at 190, 380, and 805 mV for the three settings of the sensitivity switch.

The tone controls had a rather moderate range of 8 to 9 dB maximum boost and a cut of 13 dB at the frequency extremes. The Baxandall (feedback) type BASS control had a varying inflection point that shifted from below 100 Hz to about 500 Hz as it was advanced toward its extremes. (The treble curves were hinged at about 2000 Hz.) The high-cut filter had the desirable 12 dB/octave slope, with its −3-dB point at 4700 Hz. It was effective in reducing noise, with surprisingly little effect on the audible program content.

The loudness compensation boosted both lows and highs, the former being increased below 500 Hz to a maximum of +11 dB below 50 Hz at most reduced settings of the volume control. The RIAA phono equalization was accurate to within +1/−0.5 dB from 20 to 20,000 Hz (within ±0.5 dB from 100 to 20,000 Hz). The cartridge inductance had only a slight effect on the frequency response, with an increase in output (instead of the usual decrease) beginning at about 4000 Hz and reaching a maximum of only 1 dB at 15,000 to 20,000 Hz.

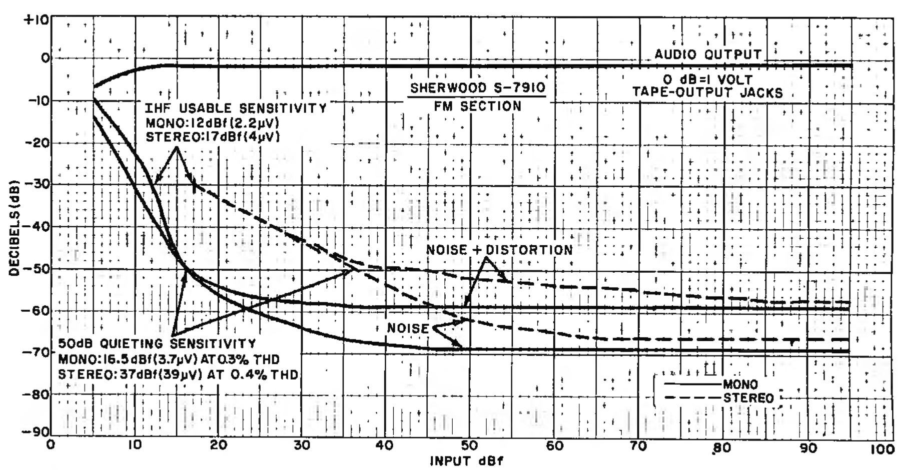
The FM tuner had an IHF usable sensitivity in mono of 12 dBf (2.2 μV). In stereo, it was 17 dBf (4 μV), which was also the threshold for automatic stereo operation. The steep limiting curve gave a 50-dB quieting sensitivity of 16.5 dBf (3.7 μV) in mono with 0.3% THD. In stereo, it was 37 dBf (39 μV) with 0.4% THD. At a 65 dBf (1,000 μV) input, the S/N was 68.5 dB in mono and 66 dB in stereo, with respective distortion levels of 0.12% and 0.21%. The stereo distortion with 100% L − R modulation of the signal generator at a 65-dBf level was 0.38% at 100 Hz, 0.14% at 1000 Hz, and 0.1% at 6000 Hz.

The FM frequency response was very flat over the full range, varying by only +0.5 to −0.3 dB from 30 to 15,000 Hz. The stereo channel separation was extraordinary, by far the best we have yet measured for a tuner. It was 60 dB or better from 135 to 7000 Hz, reached an unbelievable 68 dB at 400 Hz, and was better than 45 dB over the full 30-to-15,000-Hz range. Doubting our measurements, since even a 50-dB separation is unusual in a tuner, we rechecked this several times, but all the measurements agreed. The AM frequency response, within ±1.5 dB from 20 to 2800 Hz and down 6 dB at 3700 Hz, was typical of the AM sections of most receivers, although the AM section of this receiver did sound better than many we have heard.

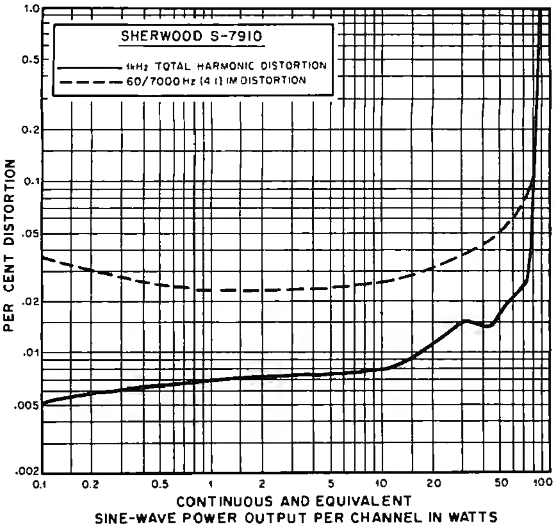
Other FM-tuner performance parameters included: capture ratio of 1.2 dB at 65 dBf, with a very good 73-dB AM rejection; image rejection of 80 dB; alternate channel selectivity of 60 dB (with perfectly symmetrical response about the center frequency, a rather unusual occurrence in FM tuners); and adjacent channel selectivity of 5.8 dB. The muting and stereo thresholds were identical at about 17 dBf (4 μV). In spite of the almost perfect response flatness up to 15,000 Hz, the 19-kHz pilot carrier leakage into the outputs was a very low −68 dB and the tuner hum was −66 dB.

User Comment. From its features and general performance, it is obvious that the Model S-7910 receiver will be a formidable competitor in the upper-medium price class. Although more power is available (from Sherwood as well as other manufacturers) at considerably higher prices, it is doubtful if most people would ever notice the difference. Certainly a conservative 60 watts of essentially distortionless audio across the full frequency range is more than enough even for most low efficiency speakers in typical home environment.

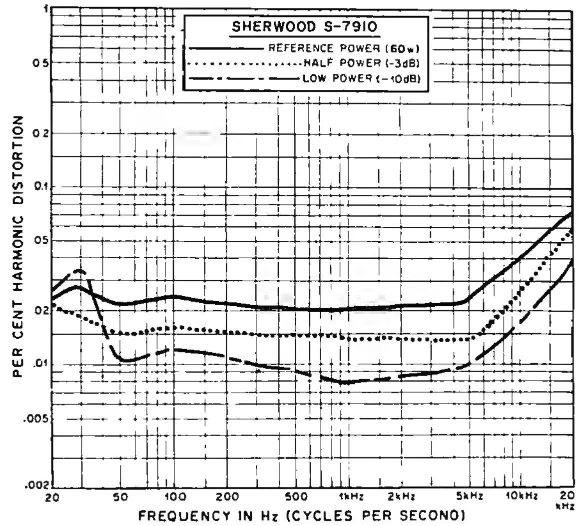
All the controls operated very smoothly. The FM muting was positive and transient-free. The dial calibration was accu-



Noise and sensitivity curves for FM section.



Total harmonic distortion and 60/70,000-Hz IM distortion.



Harmonic distortion at three power levels.

rate, with a maximum error of about 100 kHz (less than the width of the pointer). The "Positune" FM tuning indicator appeared to duplicate the function of the center channel tuning meter. The LED came on only when the meter pointer was centered on the meter's scale, signifying correct FM tuning. However, the LED is much easier to see, especially at a distance.

The sound was all one could expect from a receiver having this order of performance. Since the actual channel separation of FM broadcasts is far less than the capability of the receiver, it is unlikely that one would ever notice the 60-dB isolation between channels, but you can always be assured that you will never hear crosstalk. With almost any cartridge one might use, the most sensitive setting of the phono switch will be more than adequate in avoiding input overload. In most cases, this switch will be used to balance the levels of the phono and tuner sections. It is nice to know that *no* combination of cartridge and record can come close to the overload limits of the preamplifier.

At a time when receivers in the $750 to $1000 price range are almost common, it is reassuring to find one priced less than $500 that will match just about any of them in performance and control features, to say nothing of sound quality though with lower power output.

CIRCLE NO. 81 ON FREE INFORMATION CARD

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news HIGHLIGHTS

Film Stars Robot

A computer-controlled robot is the star of a new film entitled, "Hierarchical Control." The film, which runs for 20 minutes, demonstrates computer control techniques developed by the U.S. Commerce Department's National Bureau of Standards and how they can best be used in the automation of factories. Using simple performance tasks including stacking blocks and inserting a pin in a hole, the movie analyzes the improvements on programming speed as higher levels of control are added. The film will be made available on free loan. Write: National Bureau of Standards, Office of Developmental & Control Technology, A130, Technology Building, Washington, D.C. 20234.

FCC to Test Warehoused CB Models

Under a precedent-setting program set up by CEDA (Communications Equipment Distributors Association), representatives from FCC Field Engineering Offices will be able to select a CB radio from a participating CEDA member's warehouse and test it to see if it meets current type-acceptance standards. Although the FCC has long wanted to test the radios that consumers actually buy, rather than testing only those submitted by manufacturers, they lacked the budget to carry out such a program. The FCC said late last year that they plan to take full advantage of CEDA's program "after the first of the year, when 40-channel radios are offered for sale and the new transmitter and receiver specifications take effect."

EIA Reports Imports "Up"

For the first nine months of 1976, U.S. imports of consumer electronics equipment have increased, according to the Electronic Industries Association (EIA). Total TV receiver imports are up 95.3%, with total color up 156.2% and monochrome up 67.4%. Home radios are up 21.7%, and automobile radios are up 37.4%. Phonographs increased 123.9%; record players, changers, and turntables are up 45.9%; total tape equipment (play/record), 67.1%; and play-only tape equipment, 79.2%.

Marine Radiotelephone Misuse

The widening use of full-channel vhf/FM radiotelephones has increased the incidents of boatmen selecting improper radio channels, according to the Radio Technical Commission for Marine Services. Channel 13 has been set aside for communications directly between the masters and pilots of approaching vessels. But the reserved radio channel is in jeopardy as pleasure boatmen increasingly attempt conversations on channel 13. The Commission encourages recreational boatmen to listen to channel 13 when in the vicinity of large ships that are maneuvering, but notes that they should limit any radio contact to that necessary for safe passage of the commercial vessels.

More Computer Stores

In December 1975, Paul Terrell opened his first Byte Shop in Mountain View, Cal. Thanks to the tremendous growth of the hobby computer market, Terrell anticipated, at the end of last year, a total of 34 Byte Shops to be in operation by Christmas of 1976. . . The success of existing computer stores has also prompted Semiconductor Specialists, Inc., an industral distributor, to announce entry into the computer hobbyist market. The company plans to establish MPU Shops at all 12 of its U.S. locations, the first in the Chicago area. The MPU Shops will have working models of five μP kits, three unassembled kits, and four additional μP chips not in kit form. Two complete developmental systems will be available, and books, power supplies, tape readers, and accessories in kit form will be carried. . . . Close behind is the Computer Shack, a retail store devoted to only personal μC's and peripherals and interfaces. President Ed Faber of Computer Shack, Inc., projects a nationwide chain of 100 franchised Computer Shack retail stores by the end of 1977. Plans are to provide complete sales and service for the computer hobbyist, educational, and business user and feature a broad line of μC's and modules, books, tools, and comprehensive line of accessories. In addition, each Computer Shack will have its own game room where customers can operate μC's and peripherals in various games of skill, according to a company spokesman.

TV Process Converts B&W to Color

Imagine Shirley Temple, the Marx Brothers, and the original King Kong in full-color TV motion pictures. B.J.A. Systems Inc. has devised a process that is said to transform monotone scenes into clear, bright, realistic color images. The colorizing process is accomplished through a combination of electronic color generation, video animation, and artistic skill. Basically, B.J.A.'s artists assign color based on grey level information in the B&W TV or video signal. Using a combination of analog and digital techniques, the operator can color an entire scene. The result is a full-color version of previous monochrome footage on broadcast-quality tape or video cassette.

WWV & WWVH Broadcast Changes

The National Bureau of Standards (NBS) plans to discontinue broadcasting on 2.5, 20, and 25 MHz from WWV and 20 MHz from WWVH. All broadcasts from these standard time and frequency shortwave stations on other frequencies will continue unchanged in power and format. The reduction in the number of frequencies is expected to commence February 1, 1977. The frequencies are being dropped in a cost-saving move.


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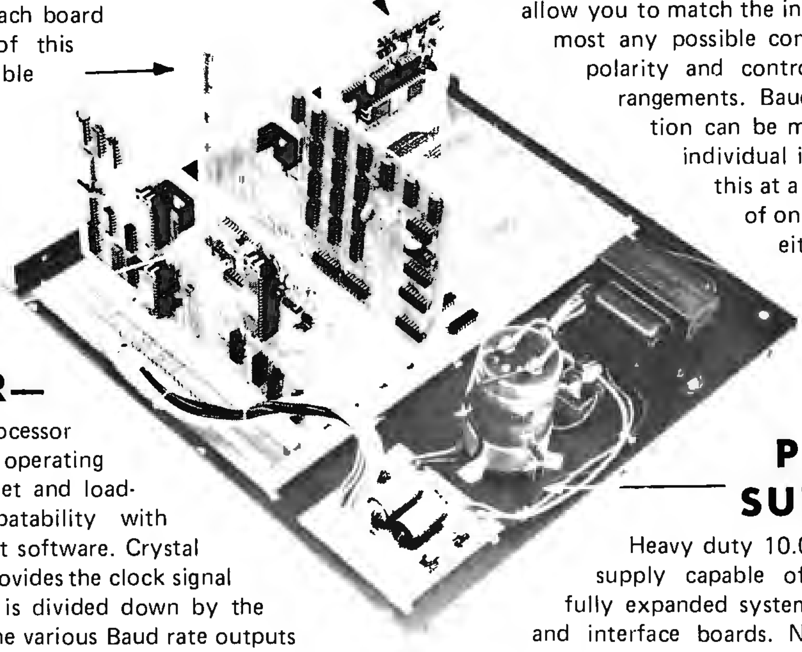

PROCESSOR—

"Motorola" M6800 processor with Mikbug® ROM operating system. Automatic reset and loading, plus full compatability with Motorola evaluation set software. Crystal controlled oscillator provides the clock signal for the processor and is divided down by the MC14411 to provide the various Baud rate outputs for the interface circuits. Full buffering on all data and address busses insures "glitch" free operation with full expansion of memory and interfaces.

POWER SUPPLY—

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DOCUMENTATION—

Probably the most extensive and complete set of data available for any microprocessor system is supplied with our 6800 computer. This includes the Motorola programming manual, our own very complete assembly instructions, plus a notebook full of information that we have compiled on the system hardware and programming. This includes diagnostic programs, sample programs and even a Tic Tac Toe listing.

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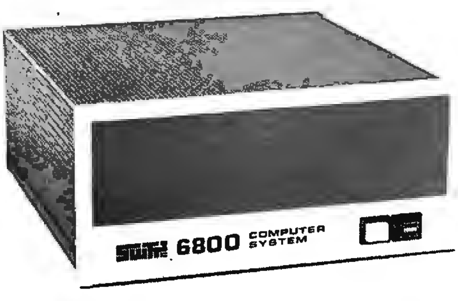
with serial interface and 4,096 words of memory. $395.00



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BY GEORGE W. RANDIG

BUILD A DIGITAL BICYCLE-SPEEDOMETER

Seven-segment LED readouts indicate speed from 1 to 99 miles per hour.

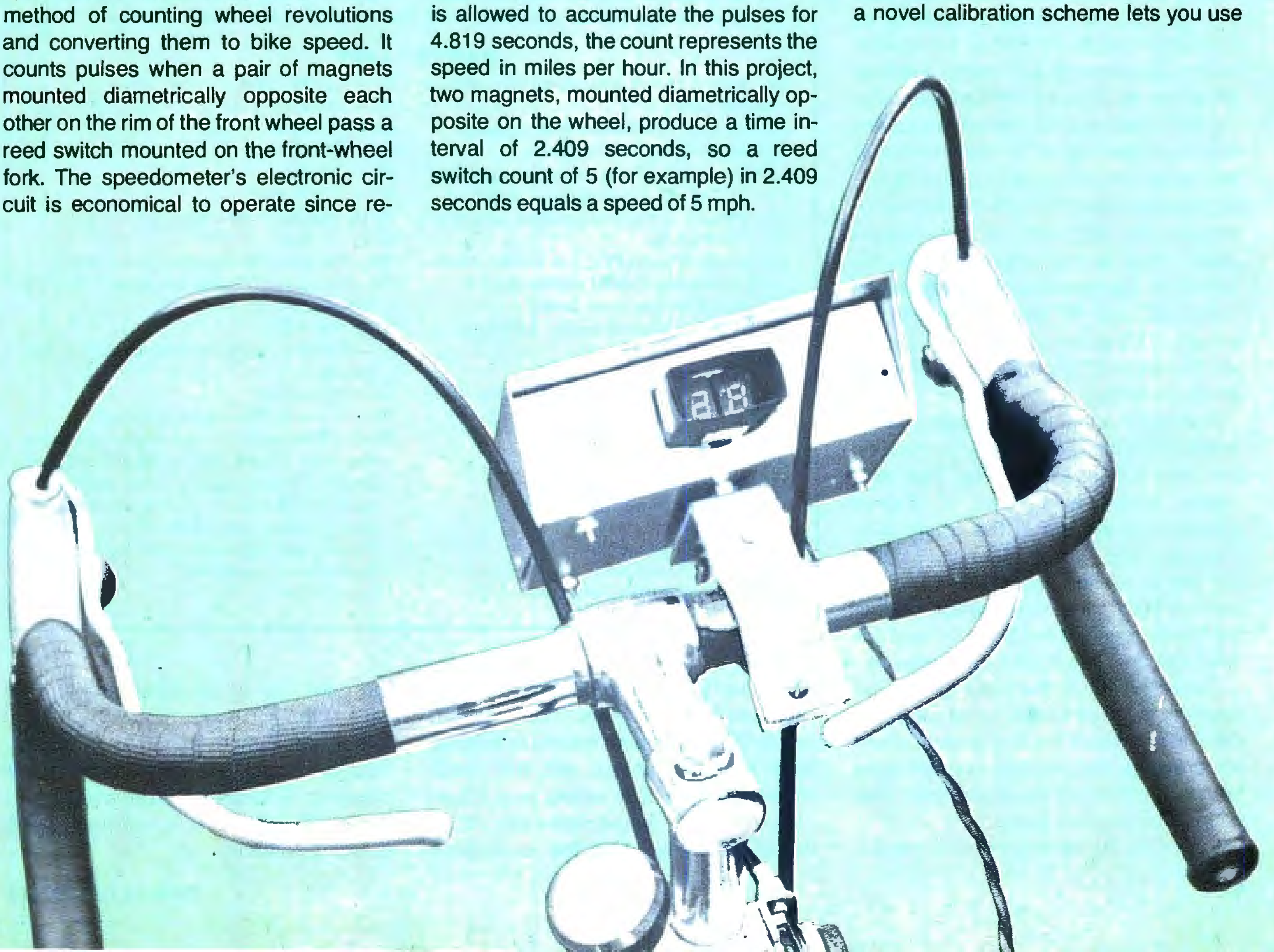
AMONG the popular bicycle accessories is the bike speedometer. This is usually a friction-producing device with an analog readout. Consequently, the cyclist has to pedal somewhat harder to overcome the friction, and the speed indicator's calibration markings are difficult to read. The digital speedometer described here overcomes these objections.

This low-cost digital LED-display speedometer incorporates a frictionless method of counting wheel revolutions and converting them to bike speed. It counts pulses when a pair of magnets mounted diametrically opposite each other on the rim of the front wheel pass a reed switch mounted on the front-wheel fork. The speedometer's electronic circuit is economical to operate since rechargeable nickel-cadmium cells supply the power.

The speedometer is capable of accurately indicating speeds from 1 to 99 mph. This is determined by the number of times the wheel rotates in a particular time interval. For example, a 27-inch diameter wheel will go through 745.96 revolutions in one mile. If the wheel is rotating at one mile per hour, it makes one revolution in 4.819 seconds. If the digital counter that is driven by the reed switch is allowed to accumulate the pulses for 4.819 seconds, the count represents the speed in miles per hour. In this project, two magnets, mounted diametrically opposite on the wheel, produce a time interval of 2.409 seconds, so a reed switch count of 5 (for example) in 2.409 seconds equals a speed of 5 mph.

The reed switch is used to drive a pair of conventional digital decade counters, each having a 7-segment LED readout, with the carry of the first (units) counter driving the second (tens) counter.

The speedometer uses two seven-segment LED displays for numeric presentation. Its magnetic pickup is a simple open-close scheme for operating the reed switch to "pulse" the input counter in the circuit. A timing circuit sets up the correct latching and reset intervals, and a novel calibration scheme lets you use



the speedometer with almost any bicycle wheel diameter. In addition, details are given on how to build a battery recharging circuit.

About the Circuit. The speedometer, shown schematically in Fig. 1, employs two decades of digital counting. Each decade contains a single IC that has a binary counter, latch, BCD-to-seven-segment decoder, and LED display driver all in one package. The carry output of *IC1* (pin 22) is used to drive *IC2*. The values of current-limiting resistors *R8* through *R21* are selected as a compromise between minimum current and acceptable brightness of the LED displays under high ambient light conditions. Resistor *R22* serves as a protective device in the event of accidental segment-to-ground shorting.

System timing is provided by half of dual timer *IC3*. The timing period is determined by the setting of calibration potentiometer *R2*. The output pulse from the timer half of *IC3*. serves as the latch signal for the two decade counters. The trailing edge of this pulse is differentiated by *C2* and *R4*, inverted by *Q1*, and then used as the reset pulse for the counting system.

The remaining half of *IC3* is used as a free-running oscillator. The output from this oscillator is coupled through *C9* to calibration switch *S3*. When the speedometer is operating, and before the bicycle wheel is placed in motion, depressing *S3* substitutes the known frequency of the oscillator signal for the wheel-rotation signal and allows adjustment of timing potentiometer *R2* until the display indicates the diameter of the bicycle wheel. This is the only calibration required by the speedometer. The values of *C3*, *R6*, and *R7* have been selected for an 11.2-pulse/second (pps) rate, which puts a 27 on the display (for 27" wheel diameter).

The input to the speedometer, via *J1*, comes from the reed switch mounted on the front fork of the bicycle. The reed switch closes each time a magnet mounted on the rim of the wheel is in close proximity with it. When the input to *IC1* (pin 2) is open, a high (logic 1) is assumed. When the reed switch closes, the input drops to zero (logic 0), and enters one count into *IC1* for each closure.

Capacitor *C7* at the input of *IC1* debounces the reed switch, while capacitor *C6* at the output of the first decade counter prevents the second counter from being incremented by more than one count for each carry pulse.

Power for the speedometer is provided by four 1.25-volt rechargeable nickel-cadmium cells in series. The cells can be recharged, without having to remove them from the project, with the circuit shown in Fig. 2. You simply plug *P2* on the recharger's output cable into *J2* on the speedometer, plug the recharger's line cord into an ac outlet, and turn on the power.

Indicator lamps *I1* and *I2* in the recharger circuit are used to limit the charging current to a safe level. Zener diode *D6* maintains a constant 6-volt charging potential.

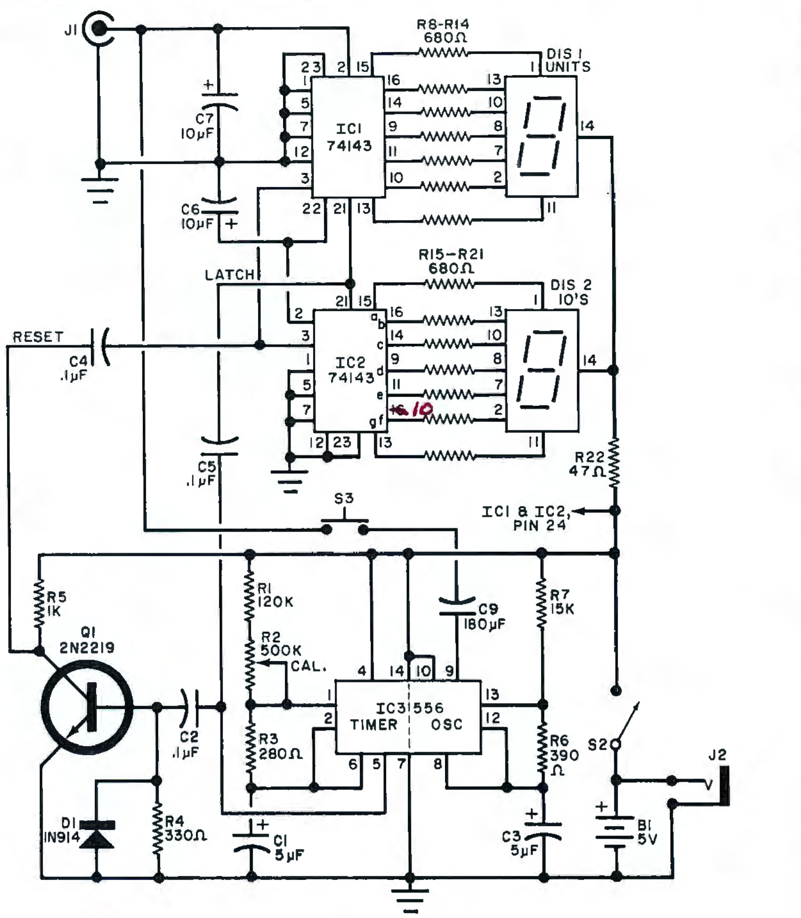


Fig. 1. Each decade counter uses one IC that includes LED driver. IC3 provides latch and reset and is also calibration oscillator.

PARTS LIST

B1—Four 1.25-volt AA-size nickel-cadmium cells in series
C1,C3—5-μF, 35-V electrolytic capacitor
C2,C4,C5—0.1-μF disc capacitor
C6,C7—10-μF, 35-volt electrolytic capacitor
C8—180-μF, 35-volt electrolytic capacitor*
C9—180-μF, 35-volt electrolytic capacitor
D1—1N914 diode
D2 through D5—50-PIV, 1-A rectifier assembly or separate 1N4001 rectifier diode*
D6—6-volt, ½-watt zener diode*
DIS1,DIS2—Common-anode LED-type 7-segment display
F1—¼-ampere fuse*
I1,I2—6-to-9-volt, 150-mA indicator lamp (#TS-47 or similar)*
IC1,IC2—SN74143
IC3—556 dual timer
J1—Phono jack
J2—Miniature phone jack
P1—Phono plug
P2—Miniature phone plug*
Q1—2N2219 transistor
The following resistors are ½-watt, 10%:
R1—120,000 ohms
R3—280 ohms
R4—330 ohms
R5—1000 ohms
R6—390 ohms
R7—15,000 ohms
R8 through R21—680 ohms
R22—47 ohms
R2—500,000-ohm miniature potentiometer
S1—Reed switch (Radio Shack No. 275-1550 or similar)
S2—Spst switch
S3—Normally open, momentary-action spst switch
S4—Spst switch*
T1—12.6-volt, 300-mA transformer*
Misc.—Two magnets (see text); enclosures for main circuit and recharger; 2-meter length of two-conductor cable; line cord*; perforated board; IC sockets (3); transistor sockets; solder clips; fuse holder*; metal U bracket; electrical tape; machine hardware; hookup wire; solder; etc.
*For recharger.

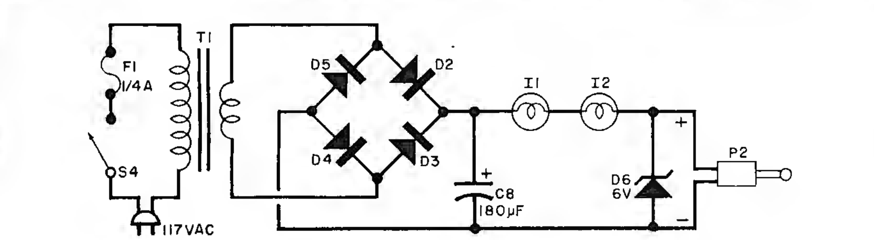


Fig. 2. Conventional regulated power supply to recharge batteries.

Construction. There is nothing critical or difficult about assembling the speedometer and its battery charger. To simplify construction, the speedometer is best assembled on two perforated boards, one for the displays and the other for the remainder of the circuit. Use sockets for the transistor and IC's and solder clips for the passive components. Hookups between the two boards and the off-the-board components can be made with lengths of insulated stranded hookup wire.

Machine the enclosure that will house the speedometer by cutting out a display window and drilling holes for *R2* and *S3* in the front panel and drilling holes for *J1, J2,* and *S3* in the rear panel. Then, secure the battery holder for *B1* to the floor of the case and mount a handlebar clamp on the bottom of the enclosure. Cement a red filter over the display window and mount the circuit board assemblies into place. Finally, connect the circuit board to the other components.

The simple recharger circuit shown in Fig. 2 can be assembled by any method you find convenient. House it in a suitable enclosure, making certain that no point on the primary side of *T1* touches the case or the circuit on the secondary side of the transformer. Mount *I1* and *I2* inside the case. (There is no need for these lamps to be mounted in holders.) The holes for the line cord and power-output cable should be lined with rubber grommets.

When both the speedometer and the recharger have been assembled and checked for proper wiring and soldering, charge the cells while you put together and mount the input assembly.

The reed switch should be cemented to a 1" long by ⅜" square (25.4 × 9.53 mm) wood block. This block is then held in place on the bicycle's front fork by a metal U bracket. (See Fig. 3 for fabrication details.) Two magnets, such as those used for cabinet doors, should be cemented with epoxy to the rim of the wheel 180° apart. Note: Do not mount the magnets on the wheel in locations where they will interfere with the caliper brake pads.

Wrap a few turns of electrical tape around the U bracket and mount the reed switch block in place as shown in photo. Once it is mounted, the reed switch block should be anchored rigidly to the front fork of the bicycle, and the reed switch should be oriented so that the magnets pass directly along its axis and within ¼" (6.35 mm) of it.

To test the input system, turn the bicycle upside down and connect an ohmmeter across the contacts of the reed switch. Slowly rotate the front wheel of the bicycle until one of the magnets passes the reed switch. As the magnet approaches the reed switch, the latter should close and produce a zero reading on the meter. As the magnet moves away from the reed switch, the contacts should open, and the meter's pointer should register infinity. Perform this test with both magnets. Then set the wheel to rotating slowly so that the magnets pass by the reed switch several times. With each pass of the magnets, the meter's pointer should momentarily deflect toward the low end of the scale.

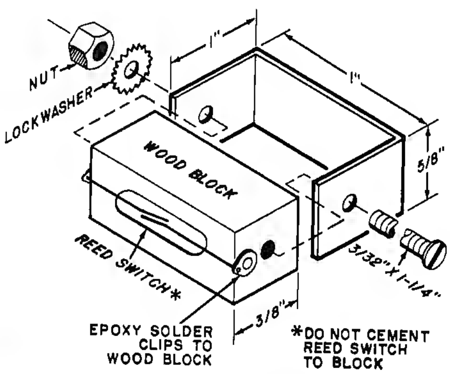
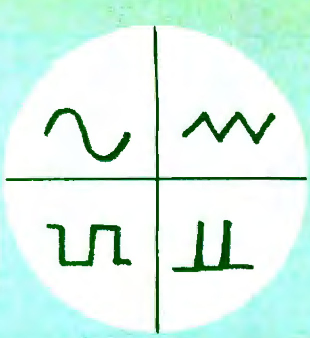


Fig. 3. Details of mounting bracket for reed relay.

Photo shows how reed relay is clamped to fork holding front wheel of bicycle with magnets (one shown) on inner rim.

With the battery pack inside the speedometer, mount the project to the handlebars of your bicycle and connect the reed-switch input to it via its cable. Now, to calibrate the speedometer, set the front wheel of your bicycle so that the reed switch is midway between the magnets. Depress calibration switch *S2* and adjust timing control *R2* until the display indicates the wheel's diameter. Release *S2,* and you are ready to pedal away—but watch your speed. ◇

BUILD THE V-4 VCO



FOR ELECTRONIC MUSIC

A low-cost voltage-controlled oscillator with sine, triangle, square-wave and pulse outputs.

BY JAMES BARBARELLO

IF YOU'RE an electronic music buff and are looking for an inexpensive but flexible VCO, this project is for you. Dubbed the *V-4*, it has four outputs—sine, triangle, and square waves and variable width pulses. It also boasts provisions for pulse-width modulation and front panel controls for sine-wave symmetry, triangle shifting, square-wave amplitude and pulse-train amplitude.

Furthermore, two *V-4* voltage controlled oscillators can be used simultaneously to produce harmony effects when teamed up to an "input multiplier." The multiplier, which is also a part of this project, amplifies the input control voltage by a constant adjustable from one to two. This allows you to produce a fundamental tone from the first *V-4* and a tone one octave above it or any fraction in between from the second.

About the Circuit. The schematic diagram of the *V-4* is shown in Fig. 1. It is a standard design using readily available components. Integrated circuit *IC2*, an Intersil 8038 VCO, is the heart of the project. Input stage *IC1*, a 741 op amp summer, processes the control voltage inputs (V_C) to produce a 0-Hz output when V_C is zero. (Multiple inputs facilitate the use of special effects such as frequency modulation, etc.) Transistors *Q1* and *Q2* form a Schmitt trigger which converts the triangle output of *IC2* into a pulse train with variable duty cycle.

The duty cycle of the pulses is determined by the setting of *R16*. Potentiometer *R17* "trims" the input to the Schmitt trigger so that minimum pulse width is obtained when *R16* is set fully counterclockwise. The amplitude of the pulse train is governed by *R22*. This control also determines the amount of hysteresis in the trigger, and therefore the minimum pulse width obtainable. For the specified component values, the duty factor is adjustable from approximately 0 to 50 percent.

Diodes *D1* and *D2* drop the supply voltage so that the potential difference from point *B* to ground (V_B) can be matched at the output of *IC1* (V_A). This is done because the two voltages must be equal for an output frequency of zero Hertz. Resistor *R12* insures that sufficient current will flow through the diodes to keep V_B constant as the current drain of *IC2* varies.

The input multiplier shown in Fig. 2 is a noninverting amplifier whose gain is adjustable from unity to two. You will recall that, in the musical scale we most commonly use, the frequency of any note is the twelfth root of two or 1.059463094 times that of the previous note. So, if a note a perfect fourth above the fundamental is desired, the control voltage must be multiplied by 1.25992105 (the twelfth root of two raised to the fourth power). The input multiplier will do this when its gain is adjusted by means of potentiometer *R26* in the feedback circuit of *IC1B*

Once this aural adjustment is made, all other tones produced will be a perfect fourth above that which would be produced at unity gain. A multiplier control input (V_C) of more than 3 volts is not useful (assuming an adjusted multiplier gain of two) because *IC2* will not respond linearly with a control input of more than 6 volts. Resistors *R6* and *R24* are used to load the unused inputs of multiplier and input stages, respectively, while generating minimum output offset voltages. If the optional input multiplier is included in the project, a 747 dual op amp should be used. As indicated in Fig. 1 and 2, *IC1* becomes *IC1A*, and the multiplier is *IC1B*.

Design Equations. You might have to vary some of the component values to suit your existing power supply and/or controller. Therefore, we will discuss the important design equations of the *V-4*. The output frequency of the 8038 is proportional to the quantity ($V_B - V_A$). For a standard controller (nominally 0 to 5 volts), we want a 0-volt input to cause V_A to equal V_B. We also want a 6-volt input (20% overrange) to cause V_A to equal the quantity $(2/3)(V_{CC} - V_{EE})$, where V_{CC} and V_{EE} are the positive and negative supply voltages, respectively. Any voltage greater than $(2/3)(V_{CC} - V_{EE})$ will cause the IC to act nonlinearly. For the circuit in Fig. 1, V_A equals $-K1\ (V_C) - K2\ (V_{EE})$. For the above constraints, $K1 = (V_B/6) - (V_{CC}/18) = R5/R1$, and $K2 = (V_B/V_{EE}) = R5/R7$. For minimum offset voltage, $R6 = R1 \,||\, R5 \,||\, R7$. Furthermore, $V_B = V_{CC} - 1.4$ V and

$$f_{OUT} = 1.5\ (V_B - V_A)/R9C1\ (V_{CC} - V_{EE})$$
$$= 1.5\ (R5/R1)\ V_C/(2V_{CC}R9C1)$$
$$\text{when } |V_{CC}| = |V_{EE}|$$
$$= K3\ V_C$$

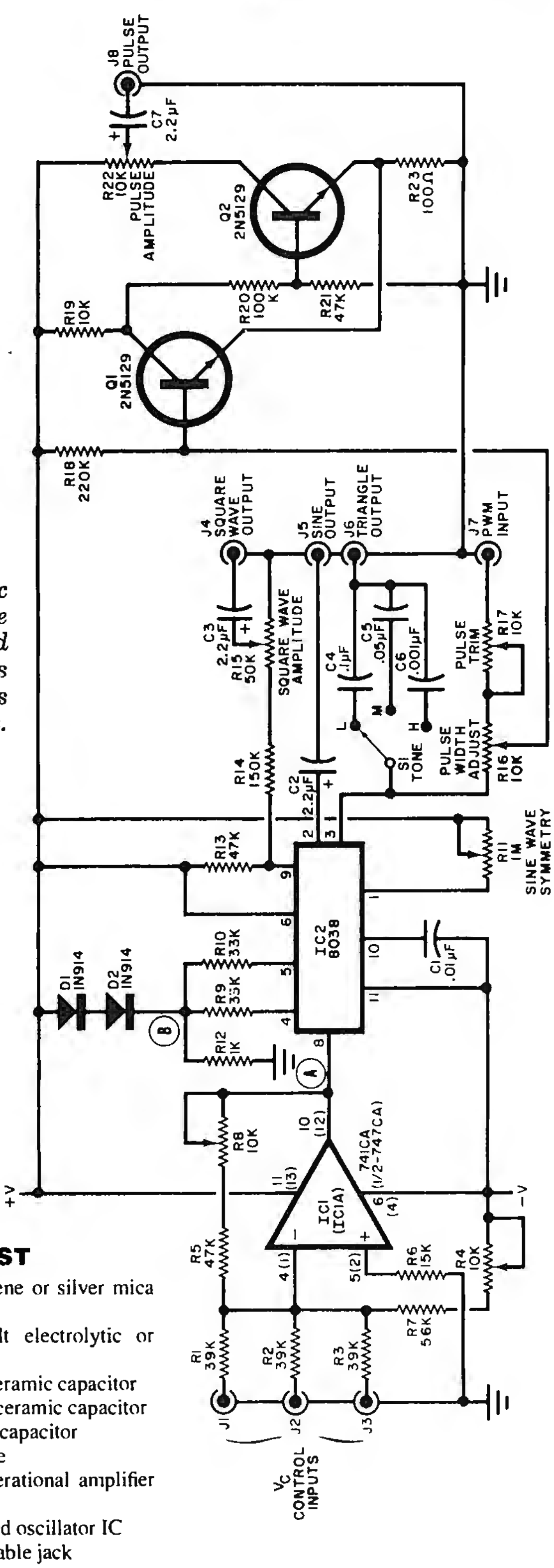


Fig. 1. Schematic of the voltage controlled oscillator shows where the various outputs are available.

PARTS LIST

C1—0.01-µF, 5% polystyrene or silver mica capacitor
C2,C3,C7—2.2-µF, 25-volt electrolytic or tantalum capacitor
C4—0.1-µF Mylar or disc ceramic capacitor
C5—0.05-µF Mylar or disc ceramic capacitor
C6—0.001-µF disc ceramic capacitor
D1,D2—1N914 silicon diode
IC1—741CA or 747CA operational amplifier IC (see text).
IC2—8038 voltage-controlled oscillator IC
J1—J8—Phono or other suitable jack
Q1,Q2—2N5129 npn silicon transistor
The following fixed resistors are ¼-watt, 10% tolerance unless otherwise specified.
R1,R2,R3—39,000 ohms
R5,R13,R21,R24—47,000 ohms
R6—15,000 ohms
R7—56,000 ohms
R9,R10—33,000 ohms, 5% max.
R12—1000 ohms
R14—150,000 ohms
R18—220,000 ohms
R19—10,000 ohms
R20,R25—100,000 ohms
R23—100 ohms
R4,R8,R17—10,000-ohm printed circuit trimmer potentiometer
R11—1-megohm linear taper potentiometer
R15—50,000-ohm linear taper potentiometer
R16,R22—10,000-ohm linear taper potentiometer
R26—100,000-ohm linear taper potentiometer
S1—1-pole, 3-position rotary switch
Misc.—Printed circuit or perforated board, suitable enclosure, hookup wire, IC and transistor sockets, knobs, machine hardware, solder, etc.

The constant K3 was chosen to be 208 to conform with the author's controller. Thus, the product $R9C1 = 0.00361\ R5/(R1\ V_{CC})$. Intersil recommends a value of *R9* (and *R10*, as the two are identical) between 10,000 and 100,000 ohms for best linearity. Because the capacitance of *C1* is on the order of 0.01 µF, a small deviation from the nominal value will affect K3 considerably. Therefore, a capacitor with as close a tolerance as possible (no more than 5%) should be used.

Given these factors, the following design steps are suggested:

1. Select a single value for *R1*, *R2*, and *R3* between 33,000 and 47,000 ohms;
2. Determine the value of *R5* using the equation
$R5 = R1\ ((V_B/6) - (V_{CC}/18))$;
3. Find the resistance of *R7* as given by the formula $R7 = R5\ (V_{EE}/V_B)$;
4. Calculate the value of *R6*
$$R6 = \frac{1}{(1/R1) + (1/R5) + (1/R7)};$$
5. Then, the product *R9C1* is determined by the equation
$R9C1 = 0.00361\ R5/(R1\ V_{CC})$
where *R9* will be between 10,000 and 100,000 ohms.

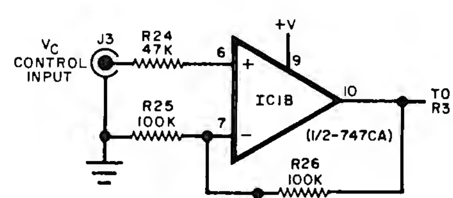
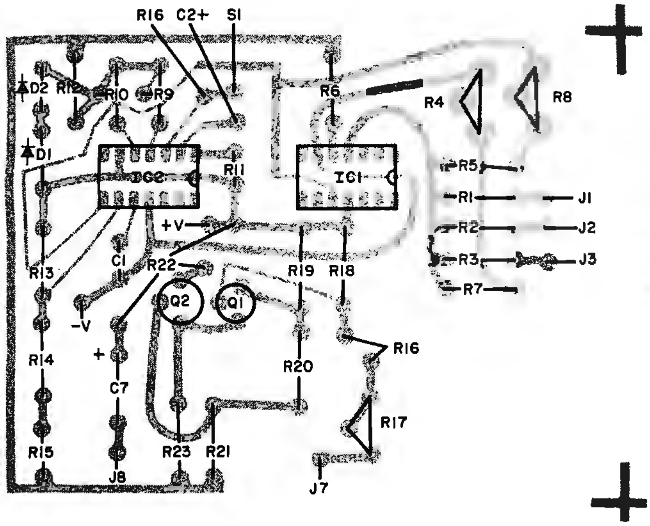


Fig. 2. Input multiplier circuit adjusts the control voltage.

Construction. The *V-4* VCO can be assembled using printed circuit or perforated board. Suitable etching and drilling and parts placement guides are shown in Fig. 3. The use of sockets for the semiconductors is recommended. Using standard components, a K3 of 217.17 was obtained. This was deemed sufficiently close to the ideal value of 208. However, trimmer potentiometers can be used in place of *R9* and *R10* to allow precise adjustment of K3. If a second *V-4* with an input multiplier is to be used with the first, trimmer potentiometers *must* be used so that its K3 can be matched to that of the first *V-4*. For best symmetry, the resistance of *R9* and *R10* should be as closely matched as possible.

Figure 4 shows modifications to the etching and drilling and parts placement



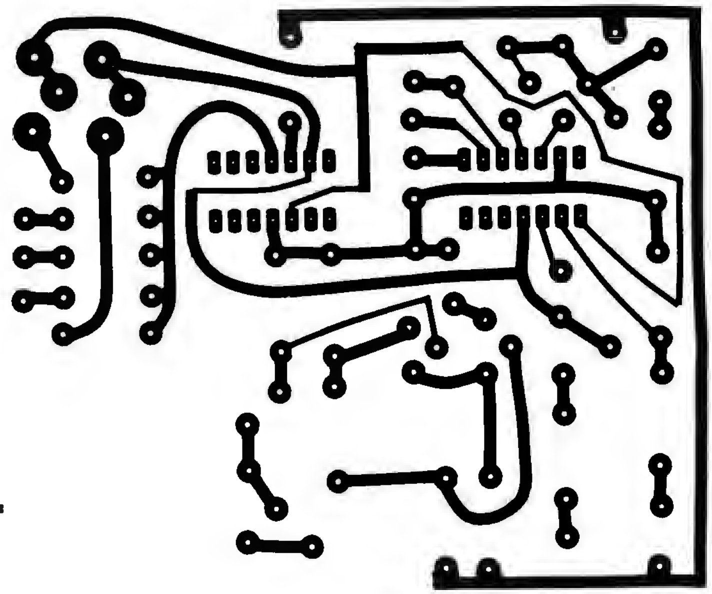


Fig. 3. Component layout diagram is shown above. Etching and drilling guide at right.

guides that must be made if an input multiplier is included. A 747 dual op amp replaces the 741 at the *IC1* location.

A suggested panel layout for the *V-4* (less input multiplier) is shown in Fig. 5. If solid wire is used for interconnection between the switches and controls on the panel and the pads on the pc board, no mounting brackets are necessary. You can use phono jacks, miniature phone jacks, banana jacks, or any other suitable type of connector for input and output signals.

Calibration. Connect the *V-4* to a *well-regulated* bipolar (±) 15-volt supply. Regulation is very important because the output frequency is proportional to the quantity $2/(V_{CC} - V_{EE})$. Then make sure your controller is providing correct control voltages. If 5 volts produces the fifth octave, 2.5 volts should produce the fourth, 1.25 volts the third, 0.625 volt the second, and 0.3125 volt the first. Before calibrating the *V-4*, check the values of V_{CC} and V_B. Determine K4 from the equation $K4 = (V_B/6) - (V_{CC}/18)$. Set trimmer potentiometers *R4* and *R8* approximately to their midpositions. Connect the positive probe of a high-impedance voltmeter to point B and the negative probe to point A.

Apply a control voltage to one of the inputs and adjust *R4* for a meter reading of ($K4\ V_C$) volts. Next, remove the control voltage and adjust *R8* for a zero-volt reading. Then, reapply the control voltage and again adjust *R4* for a reading of ($K4\ V_C$) volts. Remove the control voltage and adjust *R8* for a zero-volt reading. Repeat this procedure until no further adjustment is necessary. Then apply a control voltage and adjust *R17* for minimum pulse width with *R16* set fully counterclockwise. This completes the calibration procedure.

Using the VCO. The *V-4* can be used just like any other VCO. Keep the following guidelines in mind:

- When using the triangle output, turn *R16* (PULSE WIDTH ADJUST) fully clockwise. The HIGH and MEDIUM positions of *S1* will result in a triangle output with less low-frequency content than the LOW position. Accordingly, the output waveforms will have steeper slopes and "brighter" tones.
- The grounds of the controller and the *V-4* must be tied together.

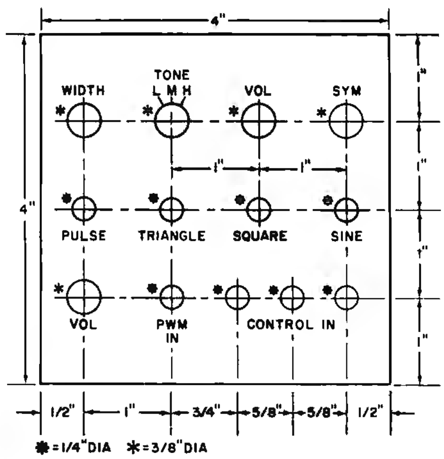
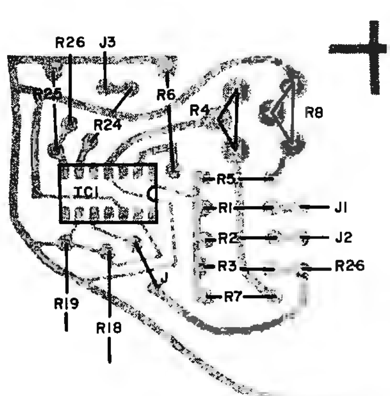


Fig. 5. Suggested layout diagram for the front panel of the V-4 without the input multiplier.

- When using the pulse width output, connect the PWM input to a control oscillator and adjust the control oscillator output for zero volt if no modulation is desired. Alternatively, the PWM input can be grounded. If this input is left floating with respect to ground, *R16* will have little or no effect on the width of the output pulses. ◇



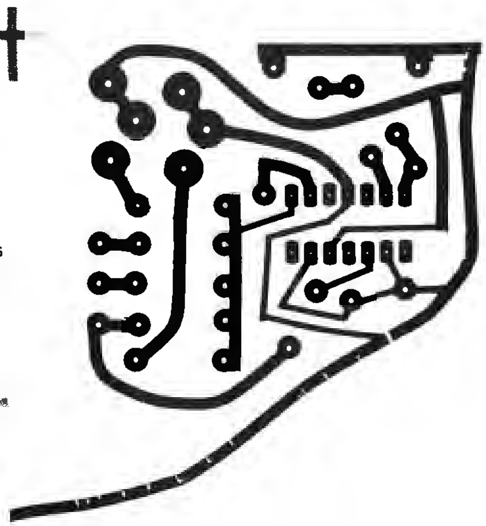


Fig. 4. Adjustments that must be made to the basic board if an input multiplier is used.

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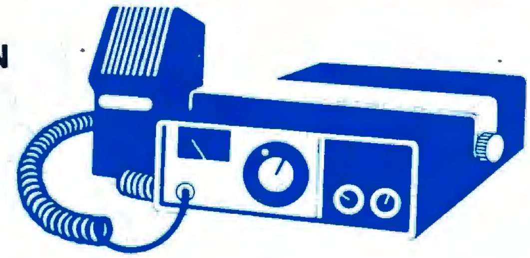
1977 Special Focus on CB RADIO

- CB RULES CHANGES FOR 1977
- PROS AND CONS OF CB FREQUENCY-GENERATION METHODS
- WILL SUNSPOTS AFFECT CB COMMUNICATIONS?
- HOW EXTERNAL SPEAKERS CAN IMPROVE CB PERFORMANCE
- BUILD A SILENCER



CB RULES CHANGES FOR 1977

THE Federal Communications Commission (FCC) dropped its big bombshell in July 1976, when it released new rules that expanded the Class D Citizens Band from 23 to 40 shared AM and SSB frequencies. The channel-expansion date was effective January 1, 1977, accompanied by a host of other revisions and new rulings.

Among the new rules are name changes, effective January 27. The Citizens Radio Service is now called the Personal Radio Services, with Class D now named the Citizens Band Radio Service. Also, Part 95 of the Rules now consists of four subparts. Only the applicable subparts need be in the possession of a licensee. Thus, CB'ers will no longer have to fight through deep technical standards, the Remote Control Service, etc.

The new band extends from 26.965 MHz to 27.405 MHz. All channels are spaced 10 kHz apart except those adjacent to one of the five Class C channels. (The sixth Class C channel is 27.255 MHz, which is the same as Class D's channel 23.) Had the FCC added more channels above 27.405 MHz, it is believed that serious intermodulation interference would have resulted.

The new channels are not numbered by the FCC. The original 23 channels were. However, the industry quickly numbered the channels 1 through 40. Can you imagine a channel selector that indicates the frequency (such as 27.395) instead of a channel number?

Until the band was expanded, 27.235, 27.245, 27.265, and 27.275 MHz were not available for CB use. The frequency 27.225 MHz is CB channel 22 and 27.255 MHz is CB channel 23. To avoid confusion, channel 23 remains at 27.255 MHz, with channel 24 (27.235 MHz) and channel 25 (27.245 MHz) interspersed between channels 22 and 23. Channels 25 through 40 extend from 27.265 MHz to 27.405 MHz in 10-kHz steps. As far as the user is concerned, the frequencies actually used do not matter; only the consecutive channel numbers need be considered.

Channel 9 (27.065 MHz) is still reserved as an *emergency* channel. Since channel 11 (27.0 5 MHz) has been restored as a general-use channel, there are now 39 AM and 78 SSB channels available for standard communication, plus channel 9.

All CB transmitters must be type-accepted by the FCC, of course. Now, however, new CB *receivers* must be certified by the FCC as well.

Most 23-channel CB sets have a heterodyne-type frequency synthesizer that employs an oscillator operable on six different frequencies in the 27-MHz region. These signals, if radiated, can interfere with land-mobile radio systems operating in the 37-MHz region of the 30-59 MHz (low vhf) land-mobile band.

Because the second harmonic of a CB signal can cause TVI (television interference) to television channel 2, and the third harmonic can interfere with the reception of TV channel 5, the new rules require that the harmonic attenuation of newly type-accepted CB transceivers be at least 60 dB, as compared to the earlier 50 dB requirement. The strength of any harmonic of a 4-watt transmitter may not exceed 4 microwatts (μW). (In the future, the FCC might increase the harmonic attenuation requirement to 100 dB, limiting the power of any harmonic of a 4-W transmitter to 0.0004 microwatt.)

The FCC now requires that, at any frequency, a signal at the antenna terminals of a CB receiver not exceed a level of 2 nanowatts and will probably tighten this standard to 0.2 nanowatt in the future. Direct radiation from the chassis may not exceed 5 μV per meter, when measured at a distance of 3 meters. Also, interference arising from the power line (base station or mobile transceiver used with an ac adapter) may not exceed 100 microvolts.

In earlier days, type-acceptance of CB transceivers appears to have been granted largely on the basis of test measurements presented to the FCC. Now, however, the FCC examines a sample transceiver. Moreover, it is expected that the Commission will sample production models, too.

Samples of 40-channel CB transceivers were not accepted for testing by the FCC until September 10, 1976, with a cutoff date of November 1 for those new rigs that would receive type-acceptance by January 1, 1977 (assuming they passed the tests). During early tests, it was found that many manufacturers had trouble limiting the *receiver's* signal radiation to the newly established 5-μV standard. Consequently, the FCC has been stretching the figure to 8 μV for actual units examined by the Commission. Furthermore, production models can get away with 15 μV on a sampling basis.

Clearly, the FCC is enabling CB radio manufacturers to phase-in the new standards, which, frankly, makes sense. Otherwise, production would be seriously curtailed and customers would be faced by higher price tags.

The new rules prohibit the use of internal or outboard adapters to permit 23-channel transceivers to be operated on the new channels (24 through 40). However, the FCC voted to authorize manufacturers to convert 23-channel transceivers, in stock as of November 1, into 40-channel units. Although new 40-channel equipment must meet the 5 μV/meter (stretched to 8μV) specification for receiver chassis radiation, converted sets may radiate up to 50 μV/meter, measured at a distance of 3 meters.

Converted CB rigs (only those 23-channel units with "digital" circuitry are likely, for economic reasons, to be "convertible" by manufacturers) must carry a special label stating that they have been converted under a special FCC waiver dated November 10, 1976.

There's nothing in the new rules that prohibits the manufacture of new 23-channel units, but they promise to be supplanted by newer models with the 17 new channels added. Manufacturers of 23-channel units that do not meet the new standards must cease production by August 1, 1977, and sales must be discontinued by January 1, 1978. (Owners of these units may continue to use them, however.)

Other Changes. Other CB radio rules changes have occurred. For example, instead of having to wait weeks for a CB license before going on the air legally, you can now issue your own "temporary permit," make up your own temporary call sign, and start transmitting immediately after buying and installing a CB transceiver! When you unpack your CB transceiver, there should be a copy of FCC Form 505, a copy of FCC Form 555-B, and a copy of Part 95, FCC Rules and Regulations (the CB rules), in the carton.

You must complete FCC Form 505, the application for a CB station license and mail it to the Federal Communications Commission, P.O. Box 1010, Gettysburg, Pa. 17326. But don't send along the $4.00 requested! Effective January 1, 1977, *CB Licenses are free!* (Rebates are expected to be sent out at a future time.) Most existing official call signs consist of three letters and four numerals (such as KDQ-1212). New ones now consist of four letters and four numerals.

Because of the high theft rate of CB mobiles, the revised FCC rules require that manufacturers engrave the unit's serial number on the chassis, making eradication difficult.

Looking Ahead. In mid-1976, the FCC formed PURAC (Personal Use Radio Advisory Committee) whose members include CB users, equipment suppliers, engineers, and others who serve the FCC in an advisory capacity. Anyone can join and attend meetings.

Standards had to be tightened so that TVI could be reduced and so that CB users would suffer less from adjacent channel interference ("bleedover" and "splatter"). With more than 7 million CB licensees operating an estimated 16 million transmitters, the problems could get worse as the CB transceiver "population" grows. Note that FCC holds the CB'er responsible for maintaining interference-free communications.

Nearly all CB transceivers are rated as being capable of nearly 100 percent modulation. Few are capable of 100 percent positive (upward) modulation, but many can achieve greater than 100 percent negative (downward) modulation on peaks. It is the negative overmodulation that causes problems. Distortion is produced and the signal can splatter onto adjacent channels or over the entire band. For this reason, the FCC is taking a hard look at modulation limiter functioning. As a result, many CB radios are no longer playing loose and fast with their AML circuitry. Therefore, expect somewhat lower modulation capability with some 40-channel rigs.

Interference from low-power (no more than 100-mW input) "walkie-talkies" used by children can be expected to abate as the FCC no longer permits such units to be manufactured for use on the CB 11-meter band. The frequency range of these two-way radio portables has been moved to 49.82-49.90 MHz—a far cry from CB's 27-MHz band. The older walkie-talkies can be used until 1983, but most will be out of service by then.

The FCC is studying the possibility of expanding the Citizens Band in the 220-225 MHz spectrum and the 890-947 MHz band. New frequencies would also serve to accommodate the hordes of new CB users that will join the throng in future years.

What about the new 40-channel rigs? There will probably be a shortage during the first quarter of this year, but production will likely catch up to demand later in the year. The 40-channel units offer 17 new, virtually unoccupied channels which will permit clearer and longer-range reception for awhile. Moreover, the widespread use of digital circuitry makes possible electronic numerical channel displays that are easier to read, can be built into a microphone, and add a certain "class" to the rig. There are many 23-channel rigs that have this feature, too. Some of the added 17 CB channels will be subject to the possibility of interference from Industrial, Land Transportation, and Public Services licensees which will share four new channels (24, 25, 26, and 27) for another three years.

In brief, there's safety in numbers with CB radios today, with close to 20-million CB radios in use throughout the country. Emergency calls, motorist assist, and just plain talk fun can be yours at modest cost—whether you are operating with 23 or 40 channels! ◇

PROS AND CONS OF CB FREQUENCY-GENERATION METHODS

BY WILFRED M. SCHERER

You'll be making a buying decision among crystal, frequency synthesizer, and phase-locked-loop digital when you pick a CB transceiver. Here's how each works and its attributes.

ALL RADIO transmitters (and most receivers) contain stages that generate r-f energy. These *oscillator* circuits vary in design and application. For example, in CB transceivers, r-f signals at two or more frequencies are required to determine the transmit and receive channels.

Responding to this challenge, manufacturers employ one of three methods of frequency generation: crystal oscillators, crystal synthesizers, and phase-

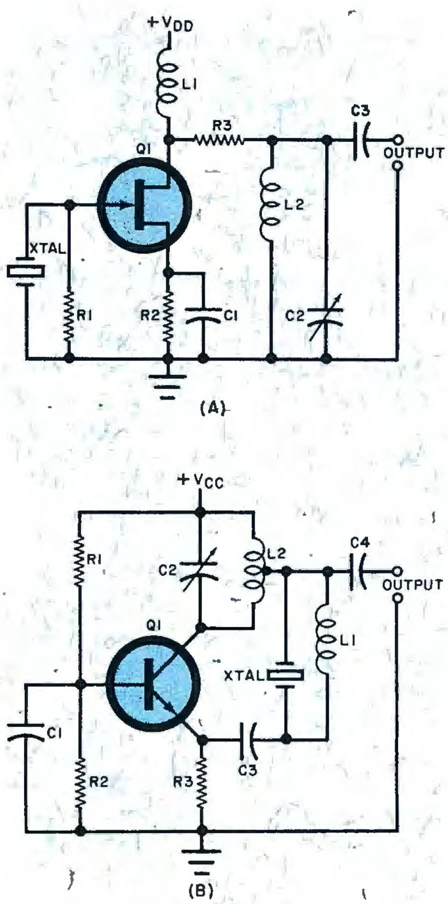


Fig. 1. Typical crystal oscillators employing field-effect (A) and bipolar (B) transistors.

locked-loop synthesizers. With the advent of 40-channel units, the latter method has been widely adopted for full-channel transceivers. Equipment with fewer channels (hand-held types, for example), however, still utilize individual crystal and crystal synthesizer systems. In this article we'll examine the strengths and weaknesses of all three approaches.

Some Basics. The receiver section of a typical transceiver is a *superheterodyne.* "Superhets" have been around for a long time, and the basic principle remains unchanged. Prior to detection, the received r-f signal is frequency shifted or converted to an intermediate frequency (i-f). This conversion is performed by the mixer stage, which heterodynes two r-f signals. That is, one signal is "beat" against another, resulting in four output signals—the two originals plus one at the sum of the two beat frequencies and one at the difference.

For example, if we heterodyne a 2-megahertz (MHz) signal with a 4-MHz one, we will obtain a signal at 6 MHz (6 MHz = 4 MHz + 2 MHz), and another one at 2 MHz (2 MHz = 4 MHz − 2 MHz). The frequencies involved in CB communications are around 27 MHz, and the i-f most commonly used is 0.455 MHz or 455 kHz.

This low i-f enables us to have receivers that exhibit high gain (to pick up weak signals) and good selectivity (to reject signals on frequencies other than that of the desired channel). To receive a Channel 13 signal at 27.115 MHz on a transceiver with a 0.455-MHz i-f, the mixer stage will beat the Channel 13 signal with one at 27.570 or 26.660 MHz supplied by a *local oscillator.* In the first case, the difference frequency (27.570-27.115) will be 0.455 MHz, and in the second, it will be 27.115-26.660, or 0.455 MHz. Note that the subtraction is made so that a positive remainder is obtained. No matter which local oscillator frequency is used, the sum frequency will be around 54 MHz. This signal will not be passed by the tuned circuits in the i-f section.

However, this receiver will suffer from poor *image rejection,* because the i-f is low compared to the original frequency, which has been mixed or converted only once. (Such a receiver is called a single-conversion unit.) It will not be able to tell the difference between the desired CB signal and one 0.91 MHz (twice the i-f) removed. For example, a 26.205-MHz signal, if it reaches the mixer, will beat with the 26.660-MHz signal and produce a 0.455-MHz output. Similarly, if a 27.570-MHz local oscillator signal is used, a signal in the 10-meter amateur band at 28.025 MHz could be picked up simultaneously (28.025 − 27.570 = 0.455).

The image signal generally can not be attenuated by more than 10 dB or so, because the r-f circuits of the receiver must pass a band of frequencies for total coverage of the CB band. These circuits are not selective enough at 27 MHz to adequately discriminate between signals 0.91 MHz apart. However, a significant improvement in image rejection can be realized by going to a higher i-f (typically 7-10 MHz). This will place the image signal much farther away from the frequencies of interest, to a point where the r-f circuits can attenuate any image that does reach them by as much as 50 to 80 dB.

Unfortunately, at higher i-f's it's not very easy to obtain high selectivity without using expensive filters, such as those used in single-sideband (SSB) equipment. Also, the gain of i-f stages at these frequencies is usually lower than those at 0.455 MHz. Therefore, *double conversion* is often used. This system employs two mixers, two local oscilla-

TABLE I

Channels	Crystal Oscillator Frequencies in MHz f_1	f_2	f_3	Channels
1-4	32.7	6.19	5.735	1, 5, 9, 13, 17, 21
5-8	32.75	6.18	5.725	2, 6, 10, 14, 18, 22
9-12	32.8	6.17	5.715	3, 7, 11, 15, 19
13-16	32.85	6.15	5.695	4, 8, 12, 16, 20, 23
17-20	32.9			
21-23	32.95			

Receive: $f_1 - f_2 - f_{sig} = 0.455$ MHz (i-f)
Transmit: $f_1 - f_3 = f_{transmit}$
Example for Channel 13
Receive: 32.850 − 6.190 − 27.115 = 0.455 MHz
Transmit: 32.850 − 5.735 = 27.115 MHz (transmitting frequency)

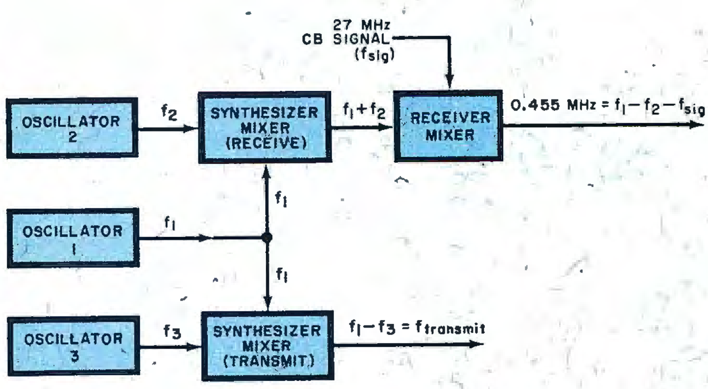


Fig. 2. Block diagram of 14-crystal, 23-channel synthesizer. Various crystal combinations are given in Table I.

tors, and thus two i-f's. The first, high i-f yields good image rejection and the second, low i-f provides high gain and selectivity.

A simple transmitter, on the other hand, does not employ heterodyning. It consists simply of an oscillator whose output is at the transmitting frequency, one or more driver stages, a modulator, and a final amplifier. However, heterodyning is used in more complex transmitters. Both types of transmitters will be examined.

Crystals and Crystal Control. Oscillators employing quartz crystals are often employed in applications (such as CB radios) demanding a high degree of frequency stability. This stability is the crystal oscillator's greatest asset, usually many times greater than that obtained from an oscillator using coil/capacitor tuned circuits as the frequency-determining elements.

The crystal oscillator's stability is derived mainly from the properties of the crystal itself, which exhibits the piezoelectric effect. That is, when physically compressed, a voltage develops across the crystal. Conversely, when a voltage is impressed across the crystal, it physically deforms. Placing the crystal in a suitable circuit (see Fig. 1.) will cause it to vibrate at a frequency determined mainly by its physical dimensions (principally its thickness).

The major disadvantage of quartz crystal frequency control is that the crystal has to be ground for *one* specific frequency, whereupon it is mounted in a sealed case. So a receiver with 40-channel capability and one intermediate frequency would require 40 individual crystals, each one ground to produce a specific output signal frequency equal to the sum of (or difference between) a particular channel frequency and the i-f. (This requirement has spurred designers to develop sophisticated circuits to reduce the crystal count, as we shall later review.)

The channel selector on the transceiver's front panel connects the appropriate crystal to the local oscillator for generation of the required frequency. More recent designs employ diode switching. That is, one side of each crystal is connected to the oscillator circuit, and the other side is connected to a switching diode, which is in turn grounded. The selector switch forward biases the appropriate diode, effectively grounding the crystal to which it is connected. All other diodes are turned off, thus keeping their crystals inactive.

It is interesting to note that the crystals in the circuits of Fig. 1 are not ground to oscillate directly at 27 MHz. Crystals capable of oscillations at such high frequencies are generally very thin and fragile, ruling out their use in high-frequency applications such as CB. Rather, *overtone* crystals are used. Here, a quartz crystal, like a violin string, can be made to physically resonate (and therefore electrically resonate) at overtones of its fundamental frequency, which does not carry the same meaning as "harmonic." The overtone is a *physical* phenomenon whose frequency differs from the harmonic due to the mechanical loading of the crystal, whereas the harmonic is an electrical phenomenon that's an integral multiple of the fundamental frequency.

Most CB crystals are specifically ground for overtone operation, and the overtone or working frequency of the crystal is stamped on its metal case.

Until a few years ago, most transceivers with 23-channel coverage used clusters of crystals. For a single-conversion receiver, 23 channels were needed. The transmitter section also required 23 crystals, but these were ground to produce outputs at the channel frequencies—not at frequencies offset from the channels by the receiver i-f—bringing the total up to 46 crystals for 23-channel transceive coverage. If a dual-conversion receiver were used, another crystal was added for the second i-f stage. Although the operating frequencies would be tightly controlled, crystal cost for this was too high.

Crystal Synthesizers. To produce CB transceivers at the lowest possible cost, manufacturers developed circuits to minimize the number of crystals needed for full CB coverage. The most common approach is called the *crystal synthesizer.* It uses the heterodyning principle to generate needed frequencies, and reduces the crystal tally down to 12 or 14 for 23-channel coverage.

In one synthesizer, one of six high-frequency crystals is mixed with one of four low-frequency crystals to produce a difference-frequency output which is the required frequency of heterodyning on receive. Similarly, one of four other low-frequency crystals is used in conjunction with one of the six high-frequency crystals to produce the transmit frequency. The various combinations required for each channel are given in Table I. The block diagram of the system is shown in Fig 2.

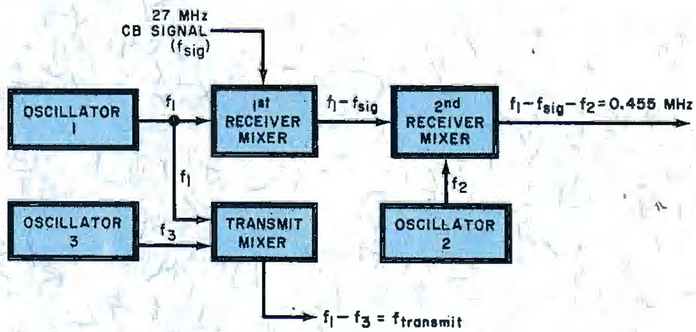


Fig. 3. This 23-channel crystal synthesizer has dual conversion on receive. Crystal combinations in Table II.

TABLE II

Channels	Crystal Oscillator Frequencies in MHz f_1	f_2	f_3	Channels
1-4	37.6	10.18	10.635	1, 5, 9, 13, 17, 21
5-8	37.65	10.17	10.625	2, 6, 10, 14, 18, 22
9-12	37.7	10.16	10.615	3, 7, 11, 15, 19
13-16	37.75	10.14	10.595	4, 8, 12, 16, 20, 23
17-20	37.8			
21-23	37.85			

Receive: $f_1 - f_{sig}$ = approximately 10.6 MHz (first i-f)
$f_1 - f_{sig} - f_2 = 0.455$ MHz (second i-f)
Transmit: $f_1 - f_3 = f_{transmit}$
Example for Channel 13
Receive: 37.75 − 27.115 = 10.635 MHz (first i-f)
37.75 − 27.115 − 10.18 = 0.455 MHz (second i-f)
Transmit: 37.75 − 10.635 = 27.115 MHz (transmitting frequency)

TABLE III

AM/SSB Crystal Synthesizer

f_1 – one of six crystal frequencies near 22 MHz
f_2 – one of four crystal frequencies near 12.8 MHz
f_3 – b.f.o. at 7.8 MHz
f_4 – 7.345 MHz
Receive:
$f_1 + f_2 - f_{sig} = 7.8$ MHz (first i-f)
$f_1 + f_2 - f_{sig} - f_4 = 0.455$ MHz (second AM i-f)
$f_1 + f_2 - f_{sig} - f_3 =$ voice frequencies
Transmit: $f_1 + f_2 - f_3 = f_{transmit}$
Example:
SSB – $22 + 12.8 - 27 = 7.8$ MHz (first i-f)
$7.8 - 7.8 =$ voice frequencies
AM – $22 + 12.8 - 27 = 7.8$ MHz (first i-f)
$22 + 12.8 - 27 - 7.345 = 0.455$ MHz (second i-f)
Transmit: $22 + 12.8 - 7.8 = 27$ MHz (transmitting frequency)

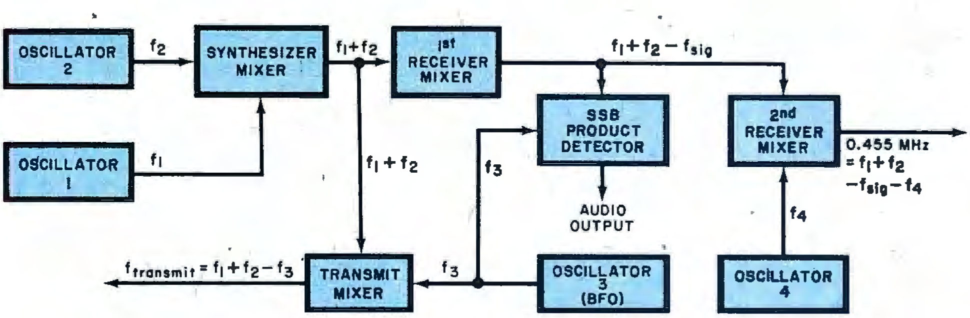


Fig. 4. Crystal synthesizer for a 23-channel AM/SSB transceiver. Crystal combinations are given in Table III.

Another standard 23-channel configuration using 14 crystals is shown in Fig. 3, but this one provides dual-conversion on receive. In this case, the first i-f is at approximately 10.6 MHz, produced by heterodyning one out of six high-frequency crystals with the received CB signal, and extracting the difference frequency. This i-f is, in turn, mixed with one of four lower-frequency crystals to produce the second 0.455-MHz i-f. Transmit frequencies are generated by single-conversion using one of the six high crystals and one of the four low crystals. The necessary combinations are listed in Table II.

The total number of crystals can be reduced to 12, but, unfortunately, reduction in crystal count is offset by the need for an extra oscillator and another mixer.

Other crystal frequencies can be used in these synthesizer sytems as long as the sum or difference signals provide the required i-f or i-f's as well as the corresponding transmit channel frequency.

Single Sideband. So far, we've considered crystal control and synthesis for AM rigs. Now, let's examine what happens in SSB gear.

Single sideband is a more efficient method to transmit information. Instead of sending two mirror image sidebands and a carrier, as is done in AM systems, SSB signals contain only one sideband and no carrier. Eliminating one sideband has no effect on the information contained in the total signal because both contain exactly the same components. The carrier, on the other hand, contains no information *in itself*, but it must be present in one way or another at the receiver for the extraction of the information in the sidebands.

If the carrier is not transmitted, the receiver must re-insert an equivalent carrier before the signal is detected. This job is handled by the *beat frequency oscillator*, whose output is mixed with the signal (usually after one or more stages of conversion) in the *product detector*. The output of the product detector, if the b.f.o. is exactly on the proper frequency (set by the *clarifier*), is a fair rendition of the other operator's voice.

SSB transceivers require sharp filters because the transceiver must ignore the other sideband, which is very close to the desired one. But since we need a narrow filter anyway, it's usually not worth going to dual conversion. The image frequencies are well removed from the operating *passband* of the filter. When single conversion is used, the basic 12-crystal synthesizer can be used with some modifications. However, this works for SSB only.

Almost all rigs that have SSB provisions also include AM, and a common arrangement used in these dual-mode transceivers is shown in Fig. 4. On SSB, single conversion to a 7.8-MHz i-f is used. Dual conversion is used for AM signals, and the first i-f is mixed down to 0.455 MHz. (See Table III.)

The 23-channel crystal synthesizers discussed are being neglected now in favor of phase-locked-loop (PLL) or digital circuitry that uses far fewer crystals. The principle is even more important in considering the new 40-channel rigs where, using crystal synthesizers, additional crystals and more complex switching would be needed.

Digital Synthesizers. Using the so-called digital or PLL synthesizer, a full-coverage transceiver requires only two or three crystals and the synthesizer itself only needs one. (The other one or two are used in heterodyning stages.)

A basic synthesizer (Fig. 5) is composed of a *reference oscillator*, a *phase-locked loop*, a Schmitt trigger, a *phase comparator*, a *low-pass filter*, and an *er-*

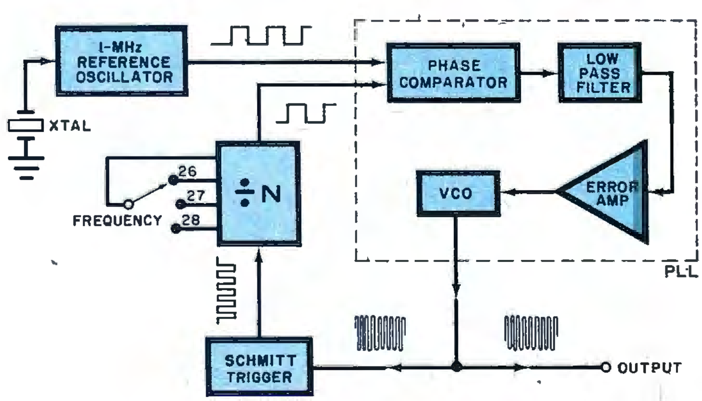


Fig. 5. A basic digital frequency synthesizer. Many frequencies can be generated using one reference crystal.

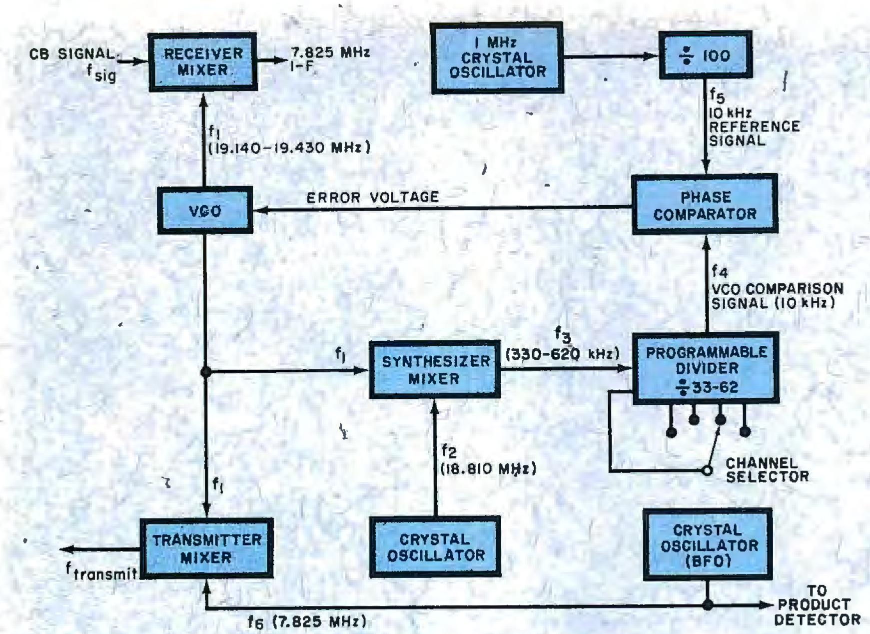


Fig. 6. A digital (PLL) synthesizer for AM/SSB use.

ror amplifier. The reference oscillator is a crystal-controlled circuit that produces a stable, known frequency which will be used as a reference. This phase comparator samples the frequencies of two input signals and produces an output voltage that is directly proportional to the frequency difference of the inputs. The low-pass filter smooths this error signal into a dc level. The voltage-controlled oscillator or VCO is an oscillator whose output frequency varies directly with the level of a control voltage applied to it. The Schmitt trigger converts sine waves into square waves, and the ÷N circuit divides the frequency of an applied square wave by a whole number, N.

Now that we've defined some essential terms, let's consider (for simplicity's sake) the operation of a synthesizer that will generate one of three separate frequencies—26, 27, and 28 MHz.

The reference oscillator produces a steady square wave (sketched at its output in Fig. 5), whose frequency is governed by a 1-MHz crystal. At the same time, the VCO is oscillating at a frequency which we'll assume to be 26.52 MHz. We'll further assume that the FREQUENCY switch in the ÷N circuit is set at 26. The output of the VCO is "squared up" by the Schmitt trigger, as shown in Fig. 5, and is divided down to 1/26th of its original frequency by the ÷N circuit. Thus, two signals are applied to the phase comparator—one at exactly 1 MHz and the other at 1.02 MHz.

The output of the phase comparator will be an error voltage because the reference frequency is lower than that of the VCO (after it has been divided down). The lowpass filter will smooth out this voltage, which is amplified by the error amplifier. The amplified error voltage is applied to the VCO, and will cause the frequency of the VCO output to decrease. As the VCO frequency approaches 26 MHz, the output of the ÷N circuit approaches 1 MHz. In turn, the error signal gets smaller and smaller, and eventually disappears when the VCO is running at exactly 26 MHz. At that point, the frequency at the ÷N output is exactly 1 MHz, and is exactly in step with the output of the reference oscillator.

If we then turn the FREQUENCY switch to 27, the VCO momentarily keeps running at 26 MHz. Its output is now divided by 27, and the frequency applied to the phase comparator is about 0.98 MHz. The resulting error voltage is smoothed, amplified, and applied to the VCO, whose frequency moves upward. As it approaches 27 MHz, the error signal gets smaller and smaller, until the VCO is running at exactly 27 MHz. A similar chain of events now occurs if the FREQUENCY switch is set at 28.

The enormous advantage of the digital or PLL synthesizer is that we can obtain any number of frequencies from the circuit merely by changing the frequency divider (÷N) circuit. All synthesized frequencies are as stable and as accurate as the one reference oscillator. Moreover, being digital, it's easy to create lighted electronic-generated numerals to identify channel numbers.

Practical Circuits. A complete PLL-synthesis system used in a 23-channel, single-conversion AM/SSB transceiver is shown in Fig. 6. The VCO operates in the 19.140-to-19.430-MHz range to provide a local oscillator signal. This signal is heterodyned on receive with the incoming CB signal, resulting in a 7.825-MHz i-f. The VCO comparison signal is obtained by first mixing the VCO output with the 18.810-MHz output of a crystal oscillator. Difference frequencies ranging from 330 to 620 kHz appear at the output of the synthesizer mixer. This, in effect, functions as an automatic predividing system.

The difference frequency for a given VCO output frequency is then divided by the programmable divider. In this stage, the amount of frequency division, ranging from ÷33 to ÷62, is determined by the setting of the channel selector. The resulting VCO comparison signal, at approximately 10 kHz, is then applied to a phase comparator, as is a 10-kHz reference signal. This reference is obtained by dividing the output of a 1-MHz, crystal-controlled oscillator by a factor of 100. The output of the phase comparator is an error voltage that shifts the VCO output until it is "on channel."

When the channel selector is set to Channel 13 and the transceiver is in the receive mode, an incoming signal at 27.115 MHz is heterodyned with the

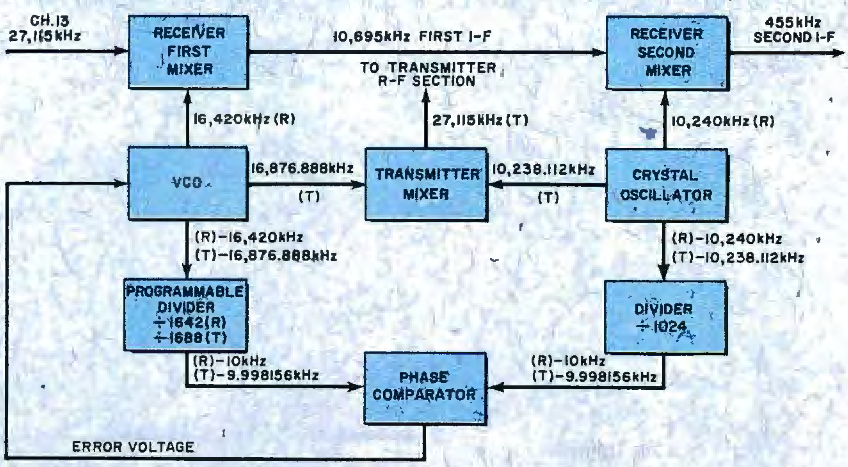


Fig. 7. Digital synthesizer for AM with dual conversion on receive.

VCO's 19.290-MHz output to produce the 7.825-MHz i-f. Simultaneously, the VCO output is beated with the 18.810-MHz crystal oscillator output, and a difference signal at 480 kHz is extracted. This is divided by a factor of 48 in the programmable divider to produce a VCO comparison signal at 10 kHz. If the VCO drifts slightly, an error voltage is produced to correct the frequency shift. On transmit, the VCO output at 19.290-MHz is heterodyned with a 7.825-MHz crystal oscillator output to produce a sum frequency of 27.115 MHz. This 7.825-MHz crystal oscillator is also used as the bfo on receive.

A PLL synthesizer for a 23-channel AM transceiver with a dual-conversion receive section (to improve image response) is shown in Fig. 7. On receive, an incoming Channel 13 signal at 27.115 MHz is heterodyned with the 16.420-MHz VCO output to generate a 10.695-MHz first i-f. (The full range of the VCO is 16.270 to 16.560 MHz.) The first i-f is then heterodyned with the output of the reference oscillator. In the receive mode, this reference signal has a frequency of 10.240 MHz. Extracting the difference signal results in a 455-kHz second i-f. The reference oscillator output is divided by a factor of 1024 and applied to the phase comparator at a frequency of 10 kHz on receive. At the same time, the VCO output is divided by a factor of 1642, and the resulting 10-kHz signal is applied to the phase comparator. For 23-channel receive coverage, the dividing factor is varied from 1627 to 1656.

On transmit, the VCO and reference oscillator outputs are heterodyned by the transmitter mixer, and the sum frequency is extracted. For this sum signal to be at the center frequency of Channel 13, the VCO output frequency must be increased 455 kHz, the i-f frequency. However, there is no integer that, when divided into the new VCO frequency, will result in a quotient of exactly 10 kHz.

The foregoing problem is solved by shifting the reference oscillator output downward by 1.888 kHz to 10.238112 MHz. Dividing this new reference by 1024 results in an output at 9.998156 kHz. Then, by increasing the new VCO frequency slightly (from 1.861 to 1.914 kHz, depending on the setting of the channel selector), and by programming the divider for a factor in the 1646-1702 range, the VCO comparison signal will also be 9.998156 kHz. The feedback arrangement of the PLL will keep the VCO and the sum of the VCO and the reference close to their ideal values.

The basic 23-channel PLL system is the obvious system used in the new 40-channel rigs. The only real modifications required are expansion of the programmable divider and the use of a VCO with wider range. Fortunately, these are readily accomplished, and some manufacturers are even offering to modify their existing 23-channel "digital" rigs for full 40-channel coverage.

The most exciting development in PLL synthesis is the development of LSI systems. That is, the production of complete PLL synthesizer circuitry in one or two large scale integrated circuits, requiring few additional external components. This methodology is clearly the wave of the future for generating frequencies for CB. ◇

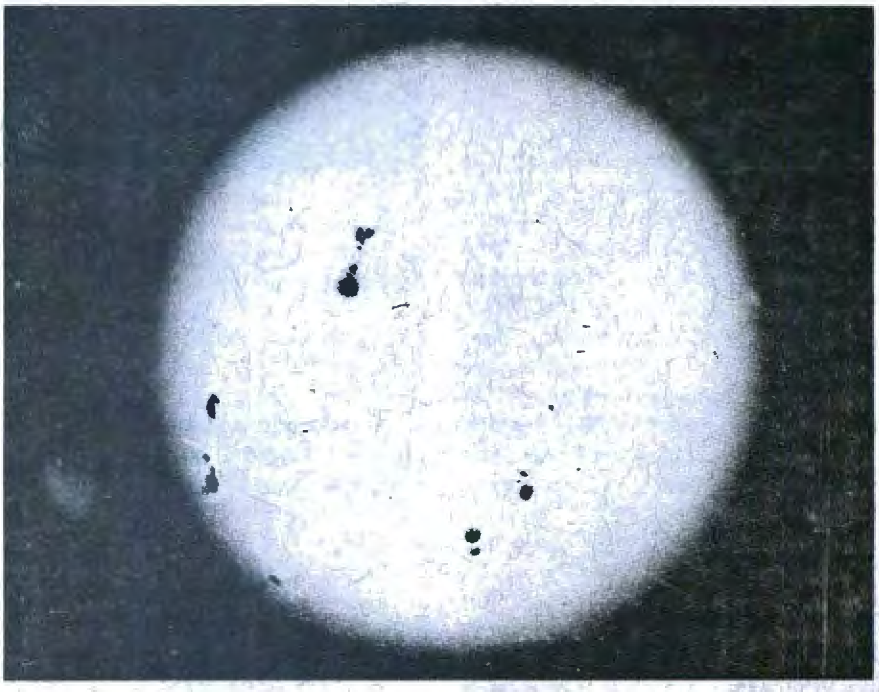
WILL SUNSPOTS AFFECT CB COMMUNICATIONS?

Sunspots, the ionosphere, and CB propagation prospects.

BY STANLEY LEINWOLL

Last summer, many CB newcomers were startled when, without warning, they heard signals coming in from great distances, in some cases, from as far as 1000 miles. Then, late in August, the phenomenon stopped as abruptly as it had begun.

The phenomenon observed was, of course, skip. It occurs when conditions are such that signals are propagated over distances far greater than their normal range. To those CB'ers who use the band for short-range two-way communications in accordance with FCC rules (150-mile maximum), skip can be a nuisance if it increases channel crowding. For some, skip is exciting and fascinating (but illegal). Although the rash of summer skip was short-lived, a new factor is coming into play that will likely increase its frequency—sunspots. Some people knowledgeable in the field of radio propagation are predicting that, in a few years, coast-to-coast skip will occur regularly. This, they assert, will cause a



The sun exhibits high sunspot activity on June 24, 1957 (U.S. Navy photo).

"traffic jam" on the Citizens Band. Others, however, including Eugene Parker, Chairman of the University of Chicago's Department of Astronomy and Astrophysics, and originator of the concept of the "solar wind," feel that no serious disruption of the Citizens Radio Service will take place.

To fully understand the propagation events that took place last summer, why the same conditions will recur this summer, and what the outlook for the 11-meter band might be for coming years, let's discuss the fundamentals of radio propagation at CB frequencies.

How a Radio Signal Travels. When a radio wave leaves a transmitting antenna, it travels outward in all directions and moves simultaneously along the ground and through space. The component that travels along the ground remains in contact with the earth until it dies out. The effect of the earth on this ground wave signal is much like that of friction on a rolling ball. The loss of energy to friction slows the ball down and finally brings it to a complete halt.

Although radio waves do not slow down (they travel at the speed of light in a given medium), their amplitudes or field strengths rapidly diminish as they move along the ground. How great the attenuation is for a specified distance depends on the type of ground over which the signal passes. In general, flat or smooth earth extracts less energy than rough or hilly terrain, and moist or rich soil attenuates less than dry, sandy, or rocky earth. In general, 11-meter ground wave signals do not travel more than five or ten miles before they are "exhausted."

The Space Wave. There is another path that signals take upon leaving the antenna. It is a straight line through the lower atmosphere. This direct or space wave propagates directly from the transmitting antenna to the receiving antenna if the two are within sight of each other. This mode of transmission is also called line of sight. Obviously, the higher above ground the antennas are, the greater the distance covered. For example, the television antennas atop the Empire State Building in New York City are mounted at heights exceeding 1,000 feet and provide line-of-sight coverage for more than 50 miles in all directions from the city. In contrast, the line-of-sight distance for antenna heights of ten feet is about three miles. If both antennas are raised to 50 feet above the ground, coverage is extended to 18 miles.

In addition to height above ground, atmospheric effects sometimes influence line-of-sight range, but these are not as significant as antenna elevation. The space wave always travels relatively short distances—rarely more than 25 to 30 miles. Its most desirable characteristic is that its range does not change radically from night to day, from one season to the next, or from year to year.

The Sky Wave and the Ionosphere. Figure 1 reveals a third component of the radiated signal, one which travels upward toward outer space. The signal is shown striking a region in the upper atmosphere and being returned to earth some distance from the transmitter. If it were not for this atmospheric region, called the ionosphere, most long-distance, high-frequency communication would be impossible, and there would be no such thing as Citizens Band DX.

The ionosphere is an electrified region which begins at an altitude of about 60 miles (97 km) and extends several hundred miles up. It has the ability to reflect radio signals in the frequency range be-

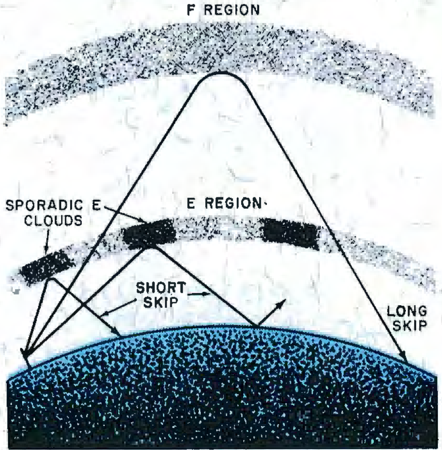


Fig. 1. Sky waves can be reflected by the E (short skip) or F (long skip) regions of ionosphere.

tween about 2 and 30 MHz and return them to earth. The radio signal that travels to the ionosphere and returns to earth is called the sky wave. From here on, our discussion will deal solely with sky-wave signals and how they depend on the ionosphere for propagation over long distances.

The ionosphere is formed primarily by ultraviolet and X-radiation from the sun, which interacts with the gases in the upper atmosphere. In the process, some of the gas atoms lose one or more electrons. A gas atom that has lost an electron is called an *ion*. Actually, the free electrons in the ionosphere are responsible for the propagation of radio waves over long distances. A radio wave entering the ionosphere causes the free electrons to vibrate. Each oscillating electron acts like a tiny antenna, and reradiates energy.

Ionization, and hence, free electrons, concentrate at different altitudes because ultraviolet radiation occurs over a relatively wide range of frequencies, and these penetrate to different levels. Because the gases in the upper atmosphere respond to various wavelengths in the ultraviolet range, there is a tendency for free electrons to concentrate into stratified layers, or regions. The most important layers of the ionosphere in terms of propagation of radio waves are the *E* and the *F* layers.

The *E* layer exists primarily during the day at an altitude of about 60 miles (96.6 km). During the daylight hours of the summer months, the *E* layer can reflect 11-meter signals up to distances of about 1000 miles (1610 km). This effect, which is sporadic in nature, is one of the most important means of propagating signals on the Citizens Band.

Sporadic-E Propagation. Sometimes, at the lower limits of the *E* layer dense clouds or patches of electrons are created. They are able to reflect frequencies much higher than normal. These clouds are random in nature and relatively short lived, lasting no more than several hours. Accordingly, they are called sporadic-*E* or E_s clouds. Because of the high electron density in E_s patches, they are often capable of propagating 11 meter signals.

Since the height of E_s is about 60 miles (96.6 km), the distance to which an E_s propagated signal can travel is limited to approximately 1000 miles (1610 km). For this reason, E_s openings are usually referred to as *short-skip* propagation, as opposed to *long skip*, in which propagation takes place via the higher *F* layers.

E_s activity varies with the time of the day and season of the year. It is most common from late spring to mid-August. There is a secondary peak during the winter months, but it is not as intense as summer activity. E_s occurs most frequently during the daylight hours, peaking in the early afternoon. This past summer E_s was also common during the evening hours.

E_s activity also varies with latitude. The further south we go, the more intense and frequent sporadic-*E* openings

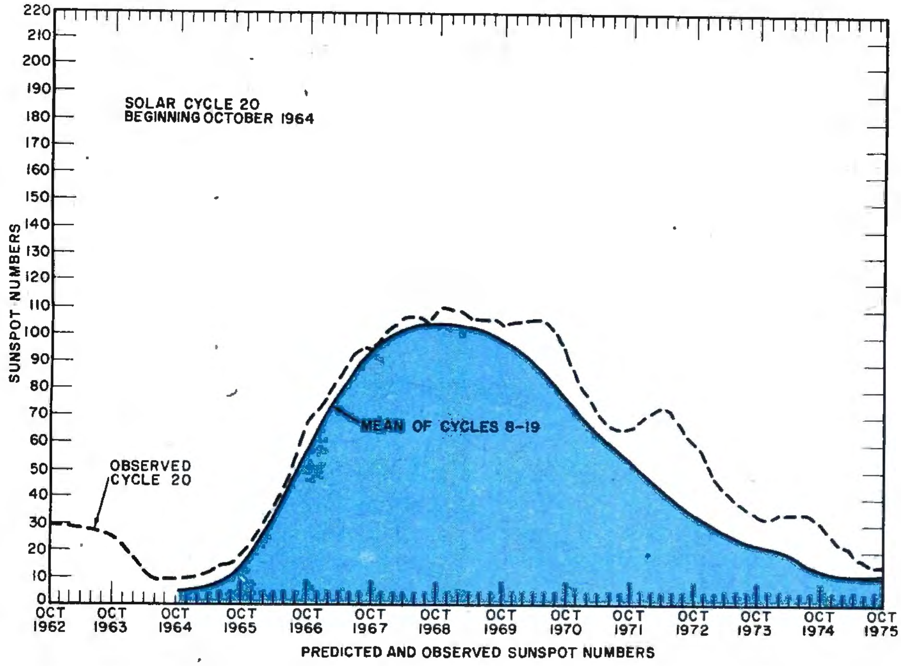


Fig. 2. Predicted and observed sunspot counts for the mean of cycles 8–19 and for the one now ending (20).

become. Consequently, circuits across the southern United States observe this effect more frequently than those in more northerly latitudes.

The mechanism that produces E_s is not clearly understood. However, a relatively recent theory of an Australian scientist, Dr. J. D. Whitehead, appears to have gained wide acceptance. Dr. Whitehead explains E_s as due to wind shears—a transient upper atmosphere condition in which the wind velocity at *E*-layer altitudes is zero, while wind velocities immediately above and below approach 200 miles per hour and are in opposite directions. When this happens, free electrons are pulled from above and below into the zero-velocity region, resulting in E_s clouds. Dr. Whitehead's theory, which also involves the action of the Earth's magnetic field, explains the seasonal nature of E_s, as well as its variation with latitude.

Long-Term Outlook—The *F* Layer. The action of E_s explains the occurrence of CB DX during the summer months. What happens during the rest of the year is dependent on events that take place in another part of the ionosphere, collectively referred to as the *F* layer.

The *F* layer is more important than the *E* layer because it is always present, day and night, season after season. It makes long-distance, shortwave communication possible. Because the 11-meter band is at the upper end of the short wave or high-frequency part of the spectrum, it has a strong influence over CB DX propagation. To understand the role of the *F* layer in CB propagation, let's briefly discuss how it changes on a daily and a seasonal basis.

The intensity of ultra-violet radiation reaching the *F* region of the ionosphere is subject to considerable variation. It changes from day to night, from season to season, and between one point on the surface of the earth to another. In addition, there are year-to-year changes which occur over an eleven-year cycle. These latter changes depend on sunspots, which emit ultraviolet radiation. Some years, there are many more sunspots than in others. Consequently, radiation from the sun is greater during those years. The ionosphere can then reflect higher frequencies than when radiation is at relatively low levels. Let's go into these variations in greater detail:

●*Diurnal Variations.* During the day radiation from the sun is most intense. As a result, ionization is at a maximum, and the frequencies that the *F* region can reflect are higher during the day than at night. At night, in the absence of direct radiation from the sun, ions and free electrons begin to recombine, and the region becomes less electrified and less dense. Consequently, it loses its ability to reflect frequencies at the high end of the shortwave spectrum. As a result, CB DX is almost *never* possible via the *F* region during nighttime hours.

●*Seasonal Variations.* It is obvious that the more hours of daylight there are in a day, the longer high frequencies will be propagated by the ionosphere. During the daylight hours, therefore, higher frequencies are reflected by the ionosphere in wintertime than those reflected in the summer.

●*Geographical Variations.* As we move towards the equator, the sun is more directly overhead for longer periods. Because the effect of radiation on the ionosphere also depends on the angle of incidence of this radiation, it is evident that the closer to the equator we are, the higher the frequencies we can expect to use.

The Sunspot Cycle. If diurnal, seasonal, and geographical variations were the only factors affecting ionization levels, then the same conditions would prevail from one year to the next at the same geographical location, and the pattern of usable frequencies over a particular circuit would be a simple matter to predict. Unfortunately, that is not the case.

One of the most important factors influencing the behavior of the ionosphere is sunspot activity. Sunspots are enormous craters of hot, whirling gases on the surface of the sun. Although the nature and origin of sunspots are not fully understood, it *is* known that they are one of the principal sources of ultraviolet radiation from the sun. Because ultraviolet radiation affects the ionosphere, the importance of sunspots is clear. Sunspots, which are imbedded in the sun, move across its face in an east to west direction as the sun rotates. It takes a spot approximately 13 days to move across the visible face of the sun. That's about half of the solar period of rotation.

In the middle of the 18th Century, accurate records of sunspots were initiated. It was observed that sunspot changes occurred in a regular manner. In Fig. 2, the solid line also shows the average of all cycles observed since the middle of the 19th Century. It can be seen that a sunspot cycle goes from minimum to maximum and back to minimum in approximately eleven years. But the cycle is not symmetrical. It takes 3 to 4 years to go from minimum to maximum, and about 7 years to go from maximum to minimum. It should be noted, however, that some cycles have been as short as nine years while others have been 13 years long.

Figures 3 and 4 illustrate the importance of sunspot activity on CB propagation. These figures show the predicted range of frequencies useful for communications between the East and West Coasts of the U.S. for the present and several years hence, when sunspot activity will have increased to the point

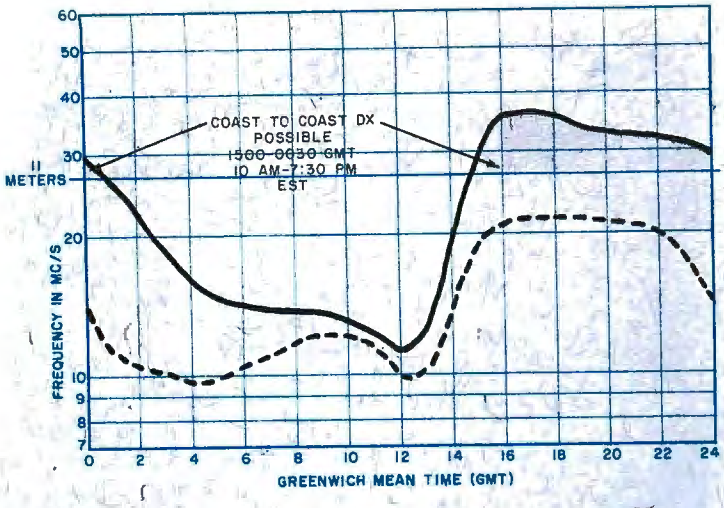


Fig. 3. Solid line is propagation curve showing highest usable frequencies during sunspot minimum and maximum in winter months.

where CB signals will propagate more regularly via the ionosphere. For the winter of 1979-80 (Figure 3) we can see that coast-to-coast reception will be a

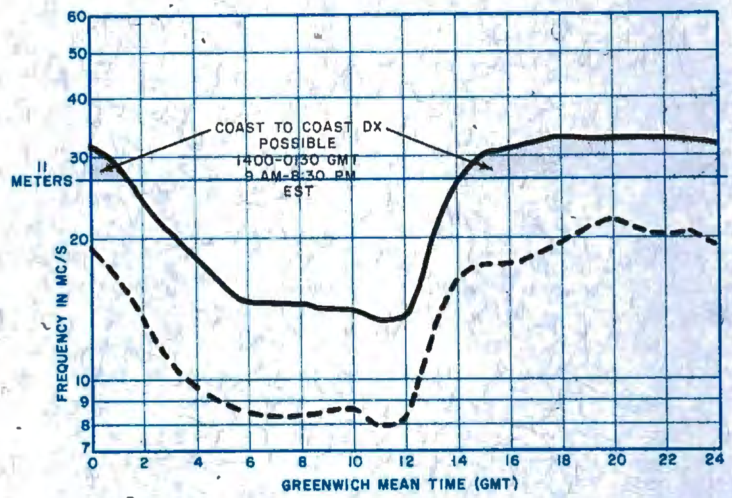


Fig. 4. Same as Fig. 3 for spring and fall. In both cases, dashed lines indicate currently useful frequencies.

possibility between the hours of 1500 and 0030 GMT or 10 a.m. to 7:30 p.m. EST. For the spring and autumn months (Figure 4), coast-to-coast reception of CB signals will at least be possible from 1400 to 0130 GMT, or 9 a.m. to 8:30 p.m. EST. In contrast, the currently useful frequencies (shown by the dashed line) indicate that no CB DX reception will be generally achievable at any time of day.

The upper limit of frequencies the ionosphere will reflect even during maximum sunspot activity also depends on the distance between the transmitter and the receiver. At periods of high sunspot activity, some DX might occur around midday for distances of about 1000 miles and beyond. The further the separation, the longer the opening.

Once the openings start occurring, how long will they last? Well, a look back at Figure 2 indicates that about half the cycle registers numbers of 90 or more. It is at that cutoff point that ionization is high enough to give more regular CB openings. We can therefore predict at this time that 1979 and a few later years should see more CB DX openings than at present, although intensity is speculative since the sunspots are not on a true regular cycle. When the foregoing sunspot peak occurs, it may be a temporary nuisance to some CB'ers and a listening bonanza for others. The difference depends on when the peak really occurs and the extent of the sunspot buildup. In any event, don't worry about it because it cannot be controlled and it will pass soon enough. ◇

HOW EXTERNAL SPEAKERS CAN IMPROVE MOBILE CB PERFORMANCE

BY STEPHEN R. DAVIS

OF ALL the accessories currently available for use with mobile CB transceivers, the external speaker is perhaps the one most often overlooked. However, the addition of such a speaker can often dramatically increase the reception by improving voice intelligibility.

A speaker, whether it is inside the transceiver cabinet or outside, converts the received and detected r-f signals into an intelligible replica of the other operator's voice. It must do so without introducing an appreciable amount of distortion, and should respond only to those frequencies which convey useful information. Let's consider the practicalities of CB speaker performance by evaluating a number of influential factors—starting with the human voice itself.

Speech Characteristics. Four basic qualities denote human speech: amplitude or intensity, frequency, harmonic content and time functions. The corresponding aural characteristics are loudness, pitch, tonal quality, and time perception or speed of sound production.

Speech is by no means constant in intensity. Some sounds are accented and loud, others are soft. The wide dynamic range of speech places special demands on the hardware in a voice communications link. Soft sounds, such as consonents, are much more likely to be washed out by ambient noise than vowels. But voice articulation, and hence intelligibility, is greatly dependent on the clear reproduction of consonants.

Male voices generally occupy the bandwidth shown in Fig. 1. The range of generated frequencies is about 300 to 6000 Hz. Vowel sounds are found from about 300 to 1000 Hz, and average about 20 dB above consonants, which are found from 1000 to 6000 Hz. This makes consonants much more vulnerable to noise than vowels, and that's why radio operators are often forced to resort to phonetics such as *Bravo, Delta,* and *Tango* to diistinguish *b, d,* and *t.* Also, some communications gear includes special signal-processing circuitry to reduce the consonant-masking effects of high-frequency noise.

Another factor influencing intelligibility is the rate of speech. Many listeners tend to miss key words in radio broadcasts when the announcer is averaging a snappy 200 words per minute. However, the 100-word-per-minute delivery by Franklin D. Roosevelt allowed an entire nation to absorb and reflect upon his famous "fireside chats." Among the time elements at work here are the lengths of individual sounds, the ratio of speech elements to pauses, and the rate at which complete words are spoken.

The Human Ear. For true communication, there must be a speaker and a listener, whether they are standing face to face or separated geographically but linked by a telecommunications network. In the latter case, the link hardware must be designed to work not only with the human voice, but also with the human ear.

The ear will accept a wider range of both sound amplitudes and frequencies than the voice is capable of producing. From the threshold of hearing—0 dB, or 0.0002 dynes/cm^2—it can tolerate inputs up to three *trillion* times greater. The average range of frequencies the ear can detect is from 20 to 15,000 Hz. However, its response depends on amplitude, as demonstrated by the famous

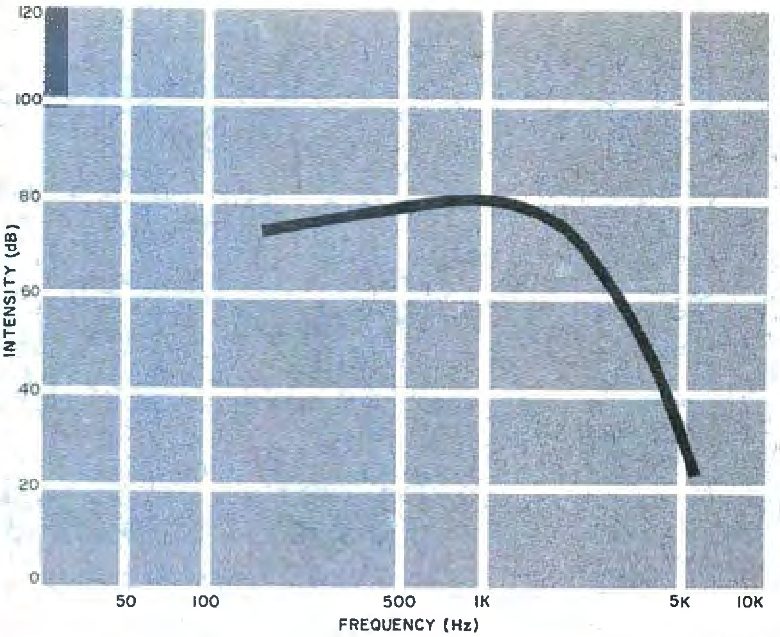


Fig. 1. Bandwidth of the average male voice.

Fletcher-Munson curves. Hearing is keenest over the 1000-to-5000-Hz segment. That's where the consonants are.

There are, however, some practical difficulties which result from the ear's response. Under certain circumstances, the ear will fail to distinguish one sound from another. This is called the masking effect, and is expressed as the increase (in dB) in the threshold of audibility of one sound when "masking" noise is introduced. It is shown graphically in Fig. 2, which indicates that it is harder to hear bass and treble sounds in a noisy environment than those in the midrange. Also, the graph shows that consonant sounds are more readily masked than vowels.

Environment. In addition to the masking effect, a host of other environmental factors influence intelligibility. Absorption of high-frequency sounds can further diminish consonant strength. Such absorption often occurs in a mobile environment when the sound does not travel directly from transducer to listener, but rather is reflected by soft surfaces. Carpeting and upholstery are the prime offenders. However, if a reflecting boundary is hard, annoying reverberations can result. In the absence of reflections and

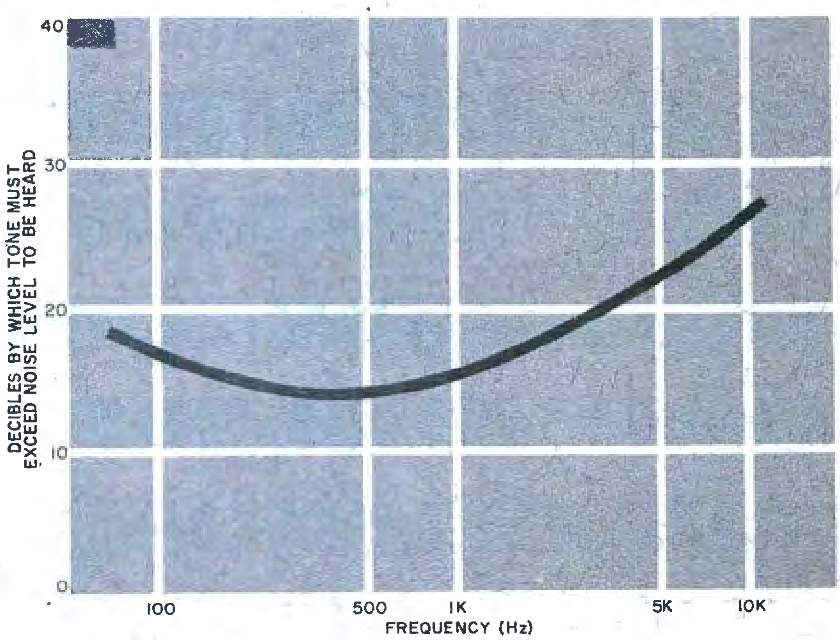


Fig. 2. When noise is present, desired sound must be increased in volume to preserve intelligibility.

Photo shows external speaker in typical under-dash position.

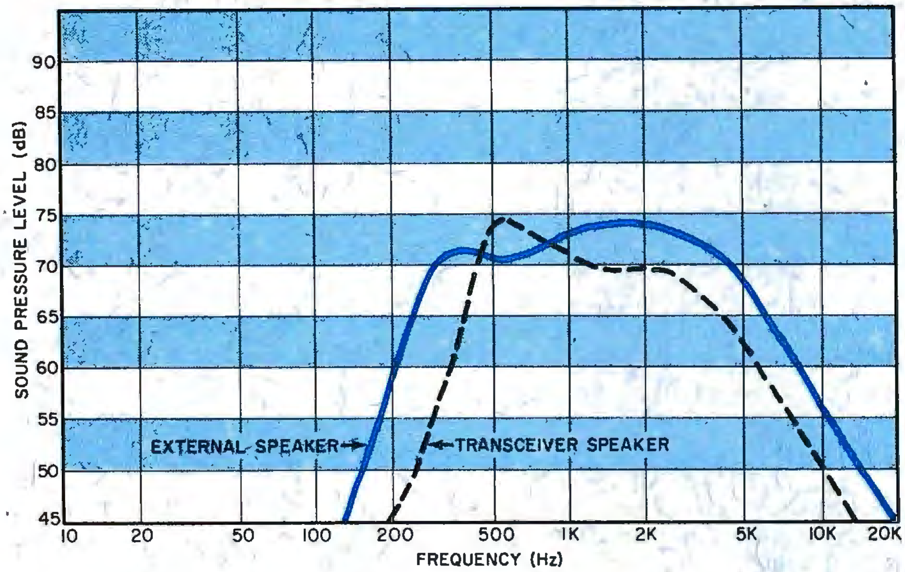


Fig. 3. On-axis response of transceiver's internal speaker (dashed) vs. Acoustic Fiber Sound Systems' "Kriket" KCS-35 external communications speaker (solid) in anechoic chamber.

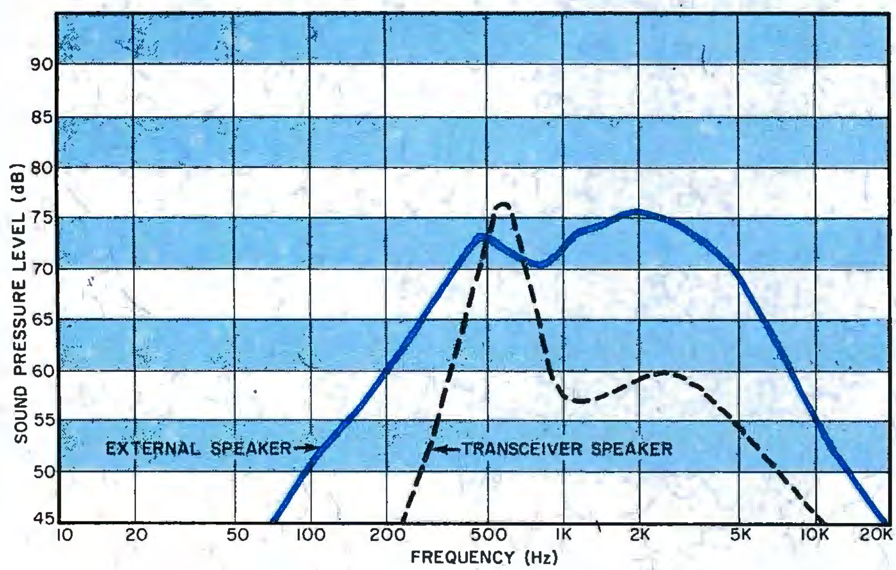


Fig. 4. Frequency response of internal (dashed) and external speaker (solid), both as mounted in typical mobile installation.

reverberation, sound levels diminish in direct proportion to the distance between the sound source and the listener. Of course, there may be sound sources present whose outputs are either above or below the bandwidth of the voice. If their levels are appreciable, intelligibility is adversely affected.

Hardware Considerations. Thus far we have considered the roles played by the human ear, voice, and the intervening environment. Now let's see how the communications gear itself affects the situation.

Properly designed voice communications systems should have an audio frequency response—both at the transmitter and receiver—which is best for those frequencies carrying the desired information. Conversely, they should ignore all sounds outside the useful bandwidth. In the course of modulation, transmission, reception, and demodulation, a minimum of electrical noise should be introduced.

To best illustrate the effects discussed, let's consider a communications system with which we are all familiar—the mobile CB installation. The mobile environment of a car, van or truck generates ambient noise in the 200-to-500-Hz range. High frequencies are attenuated by padding, carpeting, etc. Wideband (wind) noise can be considerable at highway speeds. Electrical noise can be suppressed if care is taken in grounding all parts of the vehicle body and chassis, and by shielding the ignition system if necessary. Given the sophisticated circuitry of today's CB transceivers, unwanted noise generated by the rigs themselves can be neglected.

The major weak point in most rigs is the internal speaker. For one, its frequency response is usually far from ideal. For example, the dashed curve in Fig. 3 shows the frequency response of a typical transceiver with an internal speaker, as measured in an anechoic chamber using a microphone placed one meter in front of the speaker.

This transceiver was then mounted under the dash of a standard size American automobile and its frequency response measured with the microphone positioned to coincide with the average listener's ear. The resulting response is shown as the dashed curve in Fig. 4.

Obviously, the automotive environment had a marked influence on the overall response. Because the transceiver's speaker is mounted on the underside of the enclosure, it was pointing directly towards the floor. Also, the microphone was about 120 degrees off the front axis of the speaker, and most of the sound reaching it was reflected by the carpeting and upholstery. Predictably, poor high-frequency performance was observed.

A dramatically different result was obtained with an external speaker designed for voice communications. First, a frequency response test was performed in an anechoic chamber. The solid curve in Fig. 3 is the result of this test. Then the speaker was mounted in the automobile so that its front axis of radiation was facing the listener (microphone). Again, its frequency response was measured, and appears as the solid curve in Fig. 4. The frequency response of the external speaker was broader and more uniform over those frequencies essential to voice intelligibility.

This can be explained by considering three factors. First, the external speaker has an inherently better frequency response, as indicated by the anechoic chamber tests. Second, the microphone—positioned at the location of the typical listener's ear—was on axis with the front of the external speaker. Therefore, it received the maximum portion of the high-frequency energies radiated by the speaker. Finally, because most of the sound incident upon the microphone was directly radiated by the speaker, there was minimal alteration of the audio output signal by environmental characteristics of the car's interior.

In other words, the external speaker performed comparably in both the artificial and natural environments, but the transceiver's internal speaker showed a marked degradation in performance in the car as compared to its anechoic performance. Of course, the optimum position for an external speaker would be atop the dashboard of an automobile. But this is not always advisable since it could obstruct the driver's vision. ◇

BUILD A

SILENCER

Squelches operating radio or tape player when CB signal begins.

BY RONALD MILES

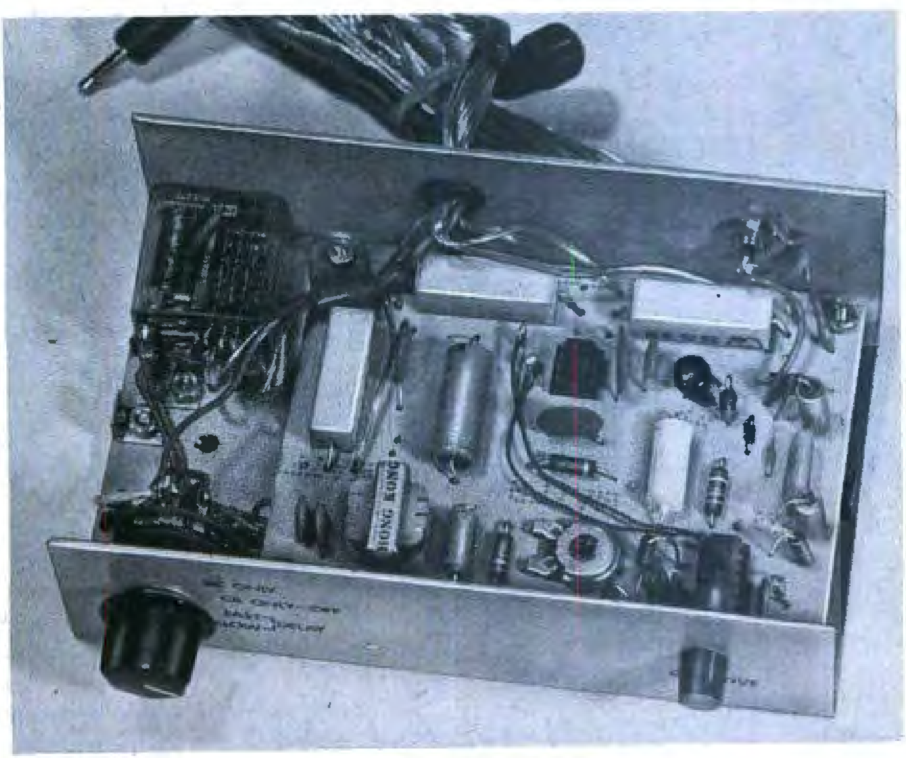


Photo of prototype shows main circuit board mounted in chassis with relay in back corner, controls on front.

MANY CB'ers are torn between listening to an auto AM/FM radio or tape player and monitoring CB calls. With both active, the sound is cacophonous when the CB receiver unsquelches. The user can manually turn down the volume of the broadcast radio or tape player every time the CB becomes active, of course, undermining driving safety.

A CB'er *can* have his cake and eat it too, however, by using the "Silencer" described in this article. It will automatically quiet the radio or tape player when the CB receiver is unsquelched or the CB transmitter is used. The entertainment system will remain silent until either the CB receiver returns to the squelched state or the CB transmitter is no longer in use. At this point, the entertainment system returns to its normal volume. No major changes to either the CB transceiver, AM/FM radio, or tape player are required.

Although designed for mobile applications, the Silencer can also be used with any receiver that has a squelch. For example, one can have a scanning monitor operating in the same room as a stereo music system; and each time the scanner stops at a station (becomes unsquelched), the audio system will be silenced until the vhf conversation is ended and the scanner resumes its normal scanning mode.

The only conditions required are that both radios should have speaker impedances of about 8 ohms; the audio power output should not exceed about 5 watts; the r-f power from the CB rig must not exceed FCC specs; and the vehicle (where used) must have a negative-ground electrical system.

How It Works. The complete schematic is shown in Fig. 1. Audio voltage

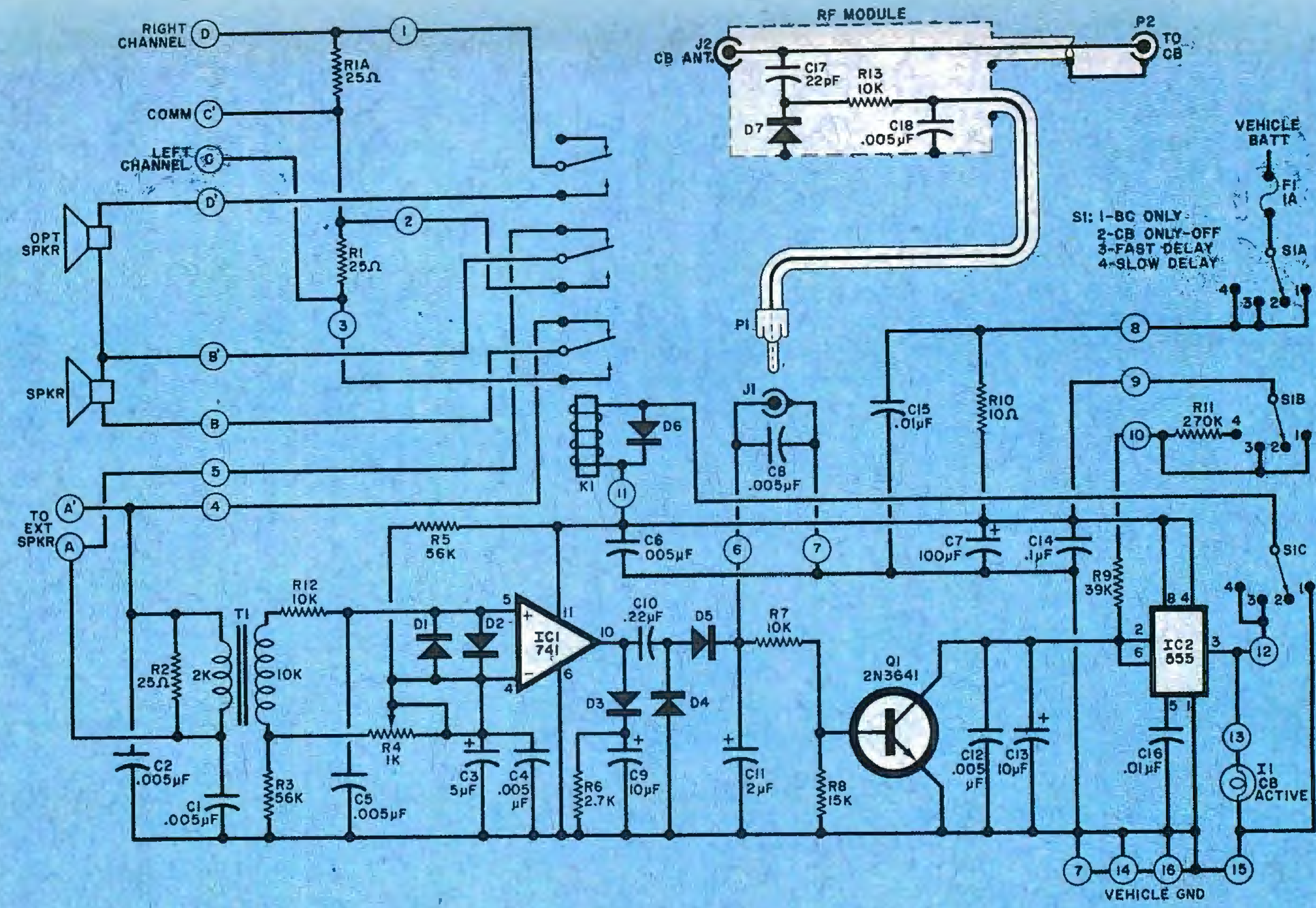


Fig. 1. Schematic of the Silencer. Circuit of the r-f module is at upper right.

PARTS LIST—R-F MODULE

C17—22-pF, 100-V mica capacitor
C18—0.005-μF, 100-V ceramic capacitor
D7—high-speed silicon diode 100 mA at 100 V (ECG 177)
J2—SO-239 coaxial cable connector
P1—phono connector to mate with J1 and suitable length of shielded audio cable
P2—PL-239 coaxial connector with suitable length of RG-58/U coaxial cable
R13—10,000-ohm, ½-watt resistor
Misc.—Suitable chassis for Silencer (Lafayette 12R03017V or similar), r-f module (Calectro H4-736 or similar), knob, L-brackets (2), press-on type, relay mounting bracket, terminal strip (three-lug), mounting hardware, spacers, grommets, etc.

PARTS LIST—BASIC SILENCER

C1,C2,C4,C5,C6,C8,C12—0.005-μF, 100-V ceramic capacitor
C3—5-μF, 25-V electrolytic capacitor (axial lead)
C7—100-μF, 25-V electrolytic capacitor (axial lead)
C9,C13—10-μF, 25-V electrolytic capacitor (axial lead)
C10—0.22-μF, 100-V capacitor
C11—2-μF, 35-V electrolytic capacitor (axial lead)
C14—0.1-μF, 50-V ceramic capacitor
C15,C16—0.01-μF, 100-V ceramic capacitor
D1 through D5—high-speed silicon diode, 100 mA at 100 V
D6—silicon rectifier diode 100 V at 1 A
F1—1-A fuse with in-line holder (Radio Shack 270-1281 or similar)
I1—12-V, 50-mA panel lamp (Radio Shack 272-323 or similar)
IC1—741 op amp
IC2—555 timer
J1—chassis mounted phono connector
K1—12-volt, 100-mA coil, 1-A contact rating. Monaural: dpdt (Radio Shack 275-206 or similar); stereo: 3pdt (Allied 88601053 or similar)
Q1—2N3641 npn silicon transistor
R1,R2—25-ohm, 5-watt resistor
R1A—same as R1, used in stereo version only
R3,R5—56,000-ohm, ½-watt resistor
R4—1000-ohm miniature potentiometer
R6—2700-ohm, ½-watt resistor
R7—10,000-ohm, ½-watt resistor
R8—15,000-ohm, ½-watt resistor
R9—39,000-ohm, ½-watt resistor
R10—10-ohm, ½-watt resistor
R11—270,000-ohm, ½-watt resistor
R12—10,000-ohm, ½-watt resistor
S1—miniature rotary switch, 4-position, 3-pole (Calectro E2-166 or similar)
T1—10k:2k miniature driver transformer (Radio Shack 273-1378, Calectro D1-722, or similar)

from the CB remote speaker output is connected to pads A and A′ so that *R2* becomes the load for the output transformer. The audio voltage generated across *R2* is applied to the primary of transformer *T1*, whose turns ratio provides a voltage step-up of five times, besides providing dc isolation.

The audio voltage on the secondary of *T1* is applied to *IC1* used as a comparator. The voltage divider combination of *R5*, potentiometer *R4*, and resistor *R3* produces a dc voltage (variable with the setting of *R4*) between the inverting and noninverting inputs of *IC1* and this voltage is adjusted so that low-level ac signals will not cause the comparator to change states.

When audio of sufficient amplitude is generated across the secondary of *T1*, parts of its cycle will cancel out the dc voltage developed across the potentiometer and the comparator will switch state with each cycle, thus acting as a very-high-gain ac amplifier whenever high-level audio comes in. Thus, *IC1* will produce an output only when the CB receiver is unsquelched.

The pulsed output from *IC1* is coupled through capacitor *C10* to a rectifier consisting of *D4*, *D5*, *C11*, and voltage divider *R7* and *R8*. When the positive voltage across *R8* exceeds one diode drop, transistor *Q1* is turned on and essentially forms a short circuit across the *IC2* timing capacitor *C13*.

Integrated circuit *IC2* is set up as a timer whose RC circuit consists of *C13*, *R9*, and, when function switch *S1* is in the SLOW DELAY position, *R11*. In the normal mode, *IC2* pin 3 is low, and no power is supplied to the CB ACTIVE lamp *I1*. When transistor *Q1* saturates, *IC2* starts its timing cycle, and if *S1* is in either the FAST DELAY or SLOW DELAY positions, relay *K1* is energized to switch the CB audio output to the speaker, and at the same time, disconnect the broadcast radio or tape player speaker. When the CB audio ceases, *IC1* no longer delivers voltage to the rectifier, and transistor *Q1* cuts off. Then *IC2* starts its timing cycle to cause *K1* to change states. The delay keeps the relay from "chattering" during any pause between words, and also keeps the broadcast radio from becoming active for a short period of time after a transmission is received, and the transmitter is activated in reply. Function switch *S1* provides a selection of fast or slow delays.

We have described how the broadcast radio or tape player is de-activated and the CB speaker comes alive when the CB receiver is unsquelched. Now we will discuss the r-f module that detects the operation of the CB transmitter and does the same switching.

As shown in Fig. 1, the separate r-f module is connected in series with the CB antenna and is "transparent" during CB reception. When the transmitter is activated, some of the r-f is rectified by *D7* and filtered by *R13* and *C18*, and the resulting dc voltage is passed via a length of shielded audio cable to the base of transistor *Q1*, in parallel with the audio signal path from *IC1*. The presence of the rectified r-f voltage starts the timer up in the same way as for the audio signal. If you do not use a CB transceiver, the r-f module may be omitted.

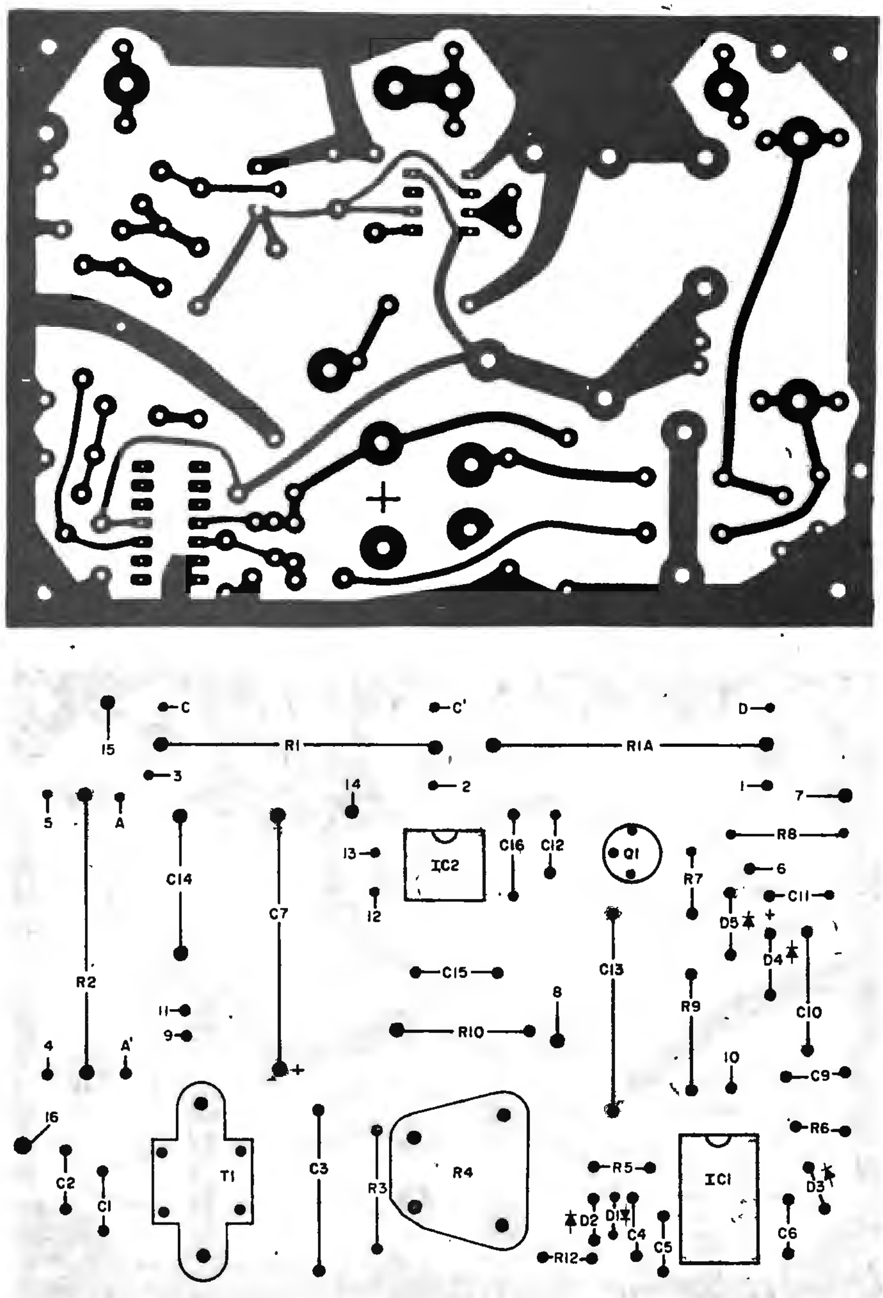
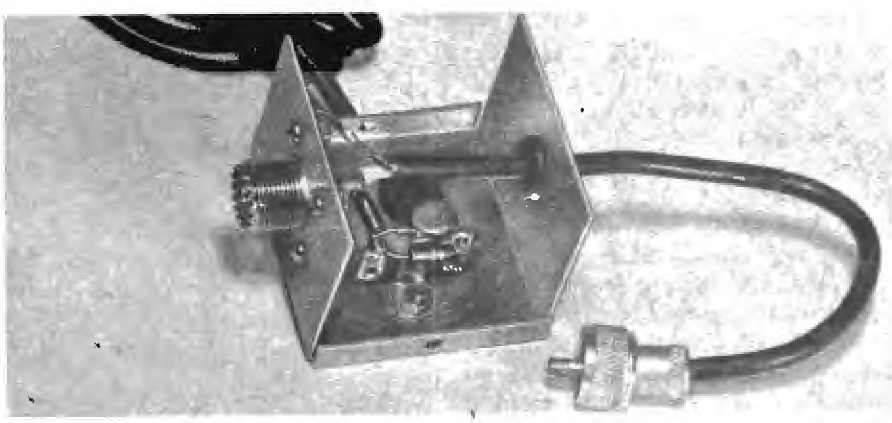


Fig. 2. Etching and drilling guide (top) and component layout for Silencer does not include r-f module components.



Components for the r-f module are assembled in their own metal enclosure and suitably connected to the rest of the circuit.

Construction. The Silencer consists of two assemblies—the basic electronics and the optional r-f module.

The basic electronics circuit has two variations. If the radio to be silenced is monaural, then resistor *R1A* can be eliminated and for relay *K1* use a double-pole, double-throw type. If you wish to silence a stereo system, then install *R1A* and use a 3-pole, double-throw relay for *K1*.

The basic electronics is assembled on a pc board such as that shown in Fig. 2,

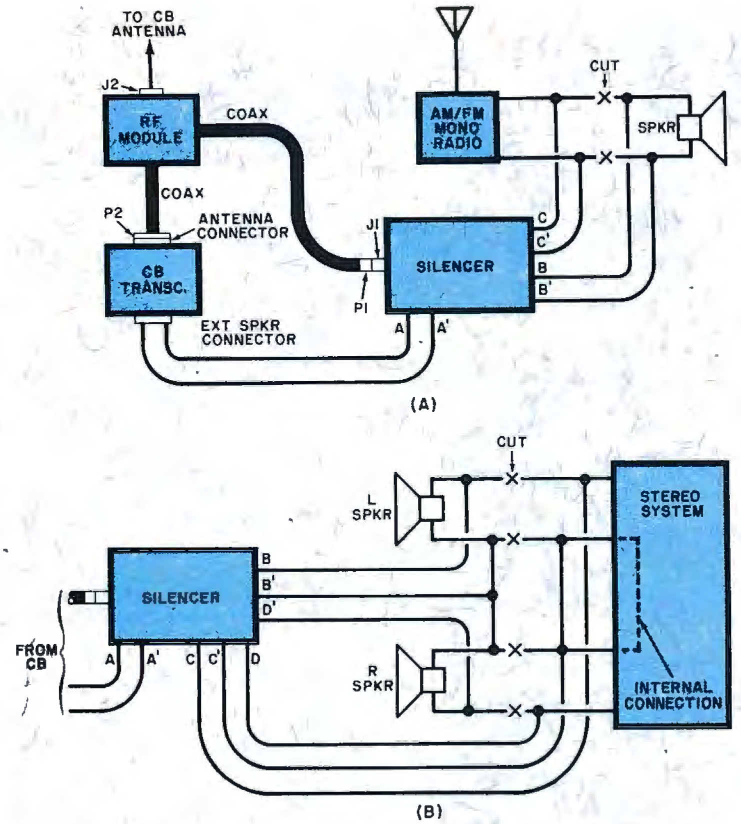


Fig. 3. To use the Silencer with a CB rig and monaural radio or tape deck, use set up at (A). For a stereo system, use (B).

which also illustrates component installation. Note that some resistors and capacitors are mounted vertically because of the narrow pad spacing, and that (optional) sockets are used for the two IC's. There must be a hole directly under the center of potentiometer *R4* so that this control can be adjusted through a mating hole in the bottom of the chassis. If you elect to use perforated board and either a wiring pencil or wire-wrap, try to keep the component installation similar to that shown in Fig. 2 to minimize stray r-f pickup by *IC1*.

The prototype basic electronics was mounted in a standard 1⅞" by 6¼" by 4⅛" metal two-piece chassis having suitable holes drilled in the front panel to mount function switch *S1*, and lamp *I1*. Jack *J1* is mounted on the rear panel, and a suitable rubber grommetted hole should be provided for the various cables. Don't forget the hole for *R4* on the underside of the chassis. Interconnections to the board are made via the small circled pads as shown in Fig. 1.

The finished circuit board is mounted on the bottom of the chassis via four small spacers, while the relay is mounted in one corner of the chassis using an L-bracket as shown in the photograph.

The r-f module is mounted in its own 2⅛" by 2" by 1¾" metal enclosure. A three-lug terminal strip is used to support the components, while connector *J2* is mounted on one wall. A length of RG-58/U coaxial cable terminated in a suitable connector for the antenna output of the CB transceiver, is passed through a grommetted hole opposite *J2*, with the coax braid connected to the grounding lug of *J2*, and to the metal chassis. The dc output of the r-f module is passed out of the metal chassis through its own coaxial audio cable that is terminated with a connector to match *J1* on the main chassis.

Installation. If you are going to use the Silencer with a CB rig in conjunction with a conventional monaural radio or tape player, use the circuit shown in Fig. 3A. Use the external speaker output of the CB transceiver for the audio output. Note that a few radio speakers may have one of their terminals grounded to the speaker frame and thus to vehicle ground. If this is the case, remove this connection from the frame, connect the Silencer as shown, and ground the corresponding lead between the Silencer and the radio.

Locate the speaker leads on the radio to be silenced and cut them. Connect the radio audio output and speaker leads as shown in Fig. 3A. If you are going to silence a stereo system (radio or tape player), then use the circuit shown in Fig. 3B. (In the case of stereo, don't forget *R1A* and the relay.)

The stereo system usually has four wires that connect to the two speakers. Use an ohmmeter to determine which pair is connected together within the stereo system (share a common, usually ground, connection), then follow the wiring of Fig. 3B.

Initial Adjustment. With the Silencer connected to the CB system as shown in Fig. 3, turn off the AM/FM radio, set the Silencer function switch (*S1*) to the CB ONLY-OFF position, and sensitivity control *R4* to its maximum resistance (minimum sensitivity) position.

Turn on the CB and set the squelch completely off. Temporarily disconnect the CB antenna from the r-f module, and adjust the CB volume so that a faint "hiss" is heard a couple of feet from the speaker. Without touching the CB, place the Silencer function switch to the FAST DELAY position, and note that after several seconds the speaker is silent.

Using an insulated screwdriver, rotate *R4* very slowly from its maximum resistance until the front-panel CB ACTIVE lamp comes on and the hiss is again heard. Reconnect CB antenna, locate an unused CB channel, and normally squelch the receiver. Key the transmitter and note that the CB ACTIVE lamp comes on and stays on as long as the transmitter is keyed. Release the transmitter switch, and after a few seconds the CB ACTIVE lamp should extinguish.

Turn on the AM/FM radio and note that its output is heard in the speaker whenever the CB is squelched, providing the transmitter is not in use. You may note that sometimes the AM/FM radio is suddenly silenced when no CB call is heard. This occurs when some CB'er touches his transmitter key momentarily without making an actual transmission. The Silencer will operate as if an actual CB signal has been received. If this occurs too often, the CB may be inadequately squelched or the Silencer too sensitive. If the relay chatters when receiving a CB call, the Silencer should be set for less sensitivity (*R4*). When the Silencer has been set for the desired CB receiver volume, lowering the volume will reduce the Silencer sensitivity.

Lastly, note that, when power is first applied to the system, the Silencer will come on in the CB mode until the delay runs out. This is normal. ◇

BY JOSEPH WEISBECKER

Build the COSMAC "ELF" Microcomputer

PART 3: How to expand memory, plus more programs

IN TWO previous articles (POPULAR ELECTRONICS, August 1976 and September 1976), we discussed the construction of the low-cost Elf microcomputer, gave some programming examples, and described some low-cost optional input/output circuits. Here we will examine some software operating systems and discuss adding 1024 bytes of memory for as little as $20.

Operating Systems. An operating system is a program that makes it easier to program and use your computer. For example, if you want to change M(43) in the basic Elf memory, you would have to start at M(00) and step through memory to location 43 before you could change it. Program 1 is a simple operating system for the Elf microcomputer. It lets you directly examine or modify any memory location. It also allows you to start program execution at any memory location. We call Program 1 ETOPS-256 (Elf Toggle OPerating System for 256-byte memory). After loading ETOPS in RAM, it can be used to help you load and run other programs.

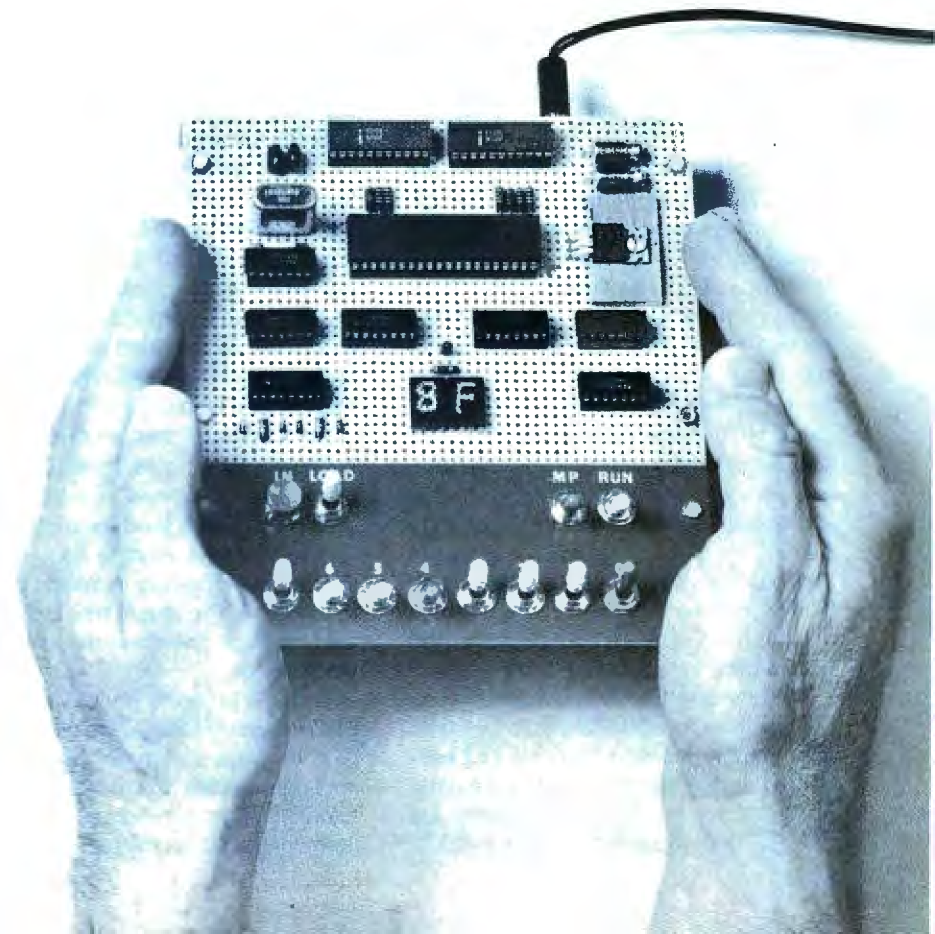
To examine a memory location using ETOPS, set 01 into the toggles. Flip the RUN switch up and 01 will be displayed. Now set the address of the memory byte you want to examine into the toggles and push the INPUT switch. The next time you push the INPUT switch, you'll see the selected memory byte displayed. Keep pushing the INPUT switch to see the sequence of bytes stored in memory.

To modify any memory location, set 02 into the toggles and turn the RUN switch up. 02 will appear. Set the address of the memory byte you want to modify (via the toggles).

Push the INPUT switch and the Q light comes on. Now set the toggles to the value of the byte you want to place in the selected memory location and push the INPUT switch to store it in RAM. You can store a sequence of new bytes by setting each byte into the toggles and pushing the INPUT switch. The Q light warns that you are modifying memory.

If you have the toggles set to 00 when you flip the RUN switch up, you can then set the toggles to the beginning address of a program you want to execute. Just push the INPUT switch to start executing your program at the selected address. Your program will begin execution with R3 as the program counter.

If you've added the battery RAM option to your system, ETOPS will be ready to use as soon as you turn on power. Since ETOPS uses only 32



PROGRAM 1--ETOPS-256

```
0000  F8  20  A1    R1.0 = work
 03   E1            X=1
 04   6C  64  21    D = toggles
 07   3F  07        Wait for IN on
 09   37  09        Wait for IN off
 0B   32  1D        M(1D) if D=00
 0D   F6  33  11    M(11) if D=01
 10   7B            Q=1
 11   6C  A1        R1.0 = toggles
 13   3F  13        Wait for IN on
 15   37  15        Wait for IN off
 17   39  1A        M(1A) if Q=0
 19   6C            M1 = toggles
 1A   64            Show M1, R1+1
 1B   30  13        Repeat M(13)
 1D   6C  A3        R3.0 = toggles
 1F   D3            P=3
 20   00            Work area
 21   User programs from
        M(21) to M(FF)
```

PROGRAM 2--EHOPS-256

```
0000  F8  FF  A2    R2.0 = work
 03   F8  23  A5    R5.0 = BSUB
 06   F8  33  A6    R6.0 = HSUB
 09   F8  0D  A3    R3.0 = M(0D)
 0C   D3            P=3
 0D   D5  A1        BSUB, R1.0=D
 0F   6C            D, M2 = toggles
 10   3A  14        M(14) if D≠00
 12   81  A3        R3.0 = R1.0
 14   F6  3B  1C    M(1C) if D=02
 17   D5  E1        BSUB, X=1
 19   64            Show M1, R1+1
 1A   30  17        Repeat M(17)
 1C   D5  E1        BSUB, X=1
 1E   51  64        M1=D, show M1, R1+1
 20   30  1C        Repeat M(1C)
 22   D3            P=3 (return)
BSUB
 23   D6            HSUB
 24   FE  FE        D left x 2
 26   FE  FE        D left x 2
 28   A0  D6        R1=D, HSUB
 2A   80  F1  52    M2=R1 or M2
 2D   64  22        Show M2
 2F   30  22        Go to M(22)
 31   F0  D5        D=M2, P=5
HSUB
 33   E2  FC  01    X=2, D+1
 36   FA  0F  52    M2=D and 0F
 39   62  22        Select key M2
 3B   3D  33        M(33) if key off
 3D   7B  F8  09    Q=1, D=09
 40   B4            R4.1=09
 41   24  94        R4-1
 43   3A  41        M(41) if R4.1≠00
 45   7A            Q=0
 46   35  46        Wait for key off
 48   30  31        Go to M(31)
```

PROGRAM 3

```
0050  F8  FF  A1      R1.0 = work
 53   F8  00  51      M1=00
 56   E1  64  21      Show M1
 59   F0  FC  01  51  M1+1
 5D   F8  10  B2      R2.1 = delay
 60   22              R2-1
 61   92  3A  60      M(60) if R2.1≠00
 64   30  56          Repeat M(56)
```

bytes, you still have 224 bytes available for your own programs.

Keyboard System. Adding a hex keyboard would make your Elf microcomputer even easier to use. With 16 keys labelled 0 through F, you would have to press only two keys for each byte you want to store in memory. In the second article, we described a circuit for monitoring the states of 16 switches or keys. (See POPULAR ELECTRONICS, Sept. 1976, page 38, Fig. 3). If you add this circuit and a 16-key hex keyboard, you can use Program 2—EHOPS-256 (Elf Hex OPerating System for 256-byte memory). This program requires 74 bytes of RAM so you still have 182 bytes left for your own programs. You can also use the hex keyboard subroutine as part of your programs if desired.

After loading EHOPS in memory, you can use it as follows. To load a byte into any memory location from the hex keyboard, set the toggles to 02 and flip the RUN switch up. The 02 toggles tell EHOPS that you want to store bytes in memory. On the hex keyboard, press the most-significant digit of a memory address followed by the least-significant digit. This address byte will be displayed and tells EHOPS where you want to start loading bytes in memory. You can now load a sequence of bytes into memory via the hex keyboard. Just press the two digits (most significant first) of each byte you want to load and they will be stored sequentially in memory starting at the selected location.

To examine any memory location (without changing its contents), set the toggles to 01 before you flip the RUN switch up. Using the hex keyboard, enter the one-byte starting address of the sequence of memory locations you want to examine. Press any hex key twice to step through memory and display the stored bytes.

To run a program you've loaded using EHOPS, set the toggles to 00 before flipping the RUN switch up. Using the hex keyboard, enter the one-byte starting address of your program. It will begin running with R3 as the program counter.

EHOPS controls the hex keyboard with two subroutines called BSUB and HSUB. BSUB calls HSUB by changing the program counter to R6 with a D6 instruction. HSUB continuously scans all 16 hex keyswitches until one is pressed. It provides a switch debounce delay and waits until the key has been released. It then returns control to BSUB with the value of the pressed key in the least-significant digit of the byte in D and M2.

BSUB is called by changing the program counter to R5 with a D5 instruction. It waits until two hex keys have been pressed before returning control to the calling program with the values of the two keys in the two digits of the byte in D and M2. The most-significant digit represents the first key pressed. Any program you write with R3 as the program counter can call BSUB to obtain a byte from the hex keyboard. If you drive a speaker with the Q lines as described in the September article, you will hear an audible click each time a hex key is pressed.

Program 3 can be loaded and run us-

PROGRAM 4

```
*C0  F8  F0  AA  RA.0=F0
 C3  F8  08  A8  R8.0=08
 C6  D5  5A      BSUB, MA=D
 C8  1A  28      A+1, R8-1
 CA  88  3A  C6  M(C6) if R8.0≠00
*CD  F8  F0  AA  RA.0=F0
 D0  F8  08  A8  R8.0=08
 D3  EA  F0  A7  R7.0=MA
 D6  64  28      Show MA, A+1, 8-1
 D8  F8  FF  AC  RC.0=FF
 DB  7B  87      Q=1, D=R7.0
 DD  FF  01      D-01
 DF  3A  DD      M(DD) if D≠00
 E1  7A  87      Q=0, D=R7.0
 E3  FF  01      D-01
 E5  3A  E3      M(E3) if D≠00
 E7  2C  8C      RC-1
 E9  3A  DB      M(DB) if RC.0≠00
 EB  88  3A  D3  M(D3) if R8.0≠00
 EE  30  CD      M(CD) if R8.0=00
 F0-F7 = Table of tone values
```

PROGRAM 5

```
0000  F8  00  B1       R1.1=00
  03  F8  FF  A1       R1.0 = work
  06  F8  00  51       M1=00
  09  E1  64  21       Show M1
  0C  F0  FC  01  51   M1+1
  10  F8  10  B2       R2.1 = delay
  13  22               R2-1
  14  92  3A  13       M(13) if R2.1≠00
  17  30  09           Repeat M(09)
```

ing either ETOPS or EHOPS: This program continuously counts up at a rate determined by the byte at M(5E). Be sure to start execution at M(50).

Program 4 should be loaded and run using EHOPS. You should also have a speaker attached to the Q line. Start this program at M(C0) with EHOPS. You can then enter eight bytes via the hex keyboard. These bytes should have values between 02 and 7F for best results. Each byte represents the frequency of a tone you will hear via the speaker. After

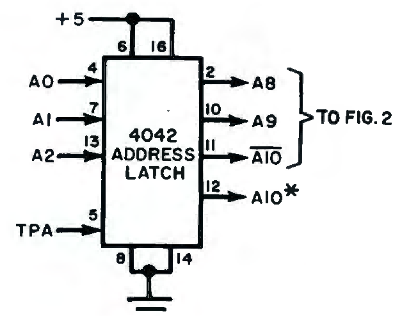
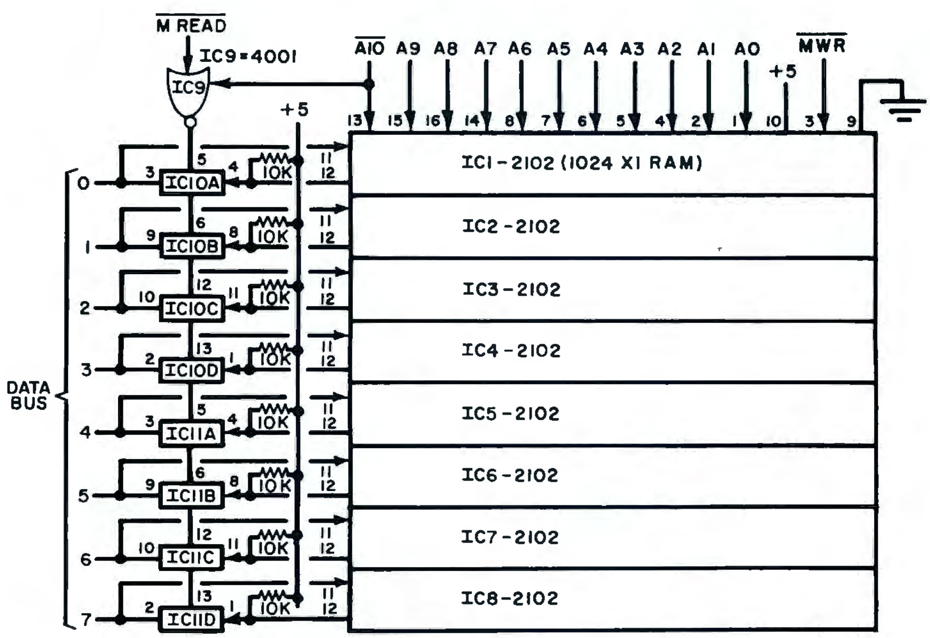


*Fig. 1. Address latch. *Connect pin 19 of original 2101 RAM's to A10 instead of ground.*

you enter the eighth byte you'll hear the eight-tone sequence repeated over and over. You can restart the program at M(CD) to hear a previously entered tone sequence.

An operating system can be designed to incorporate any desired feature. For example, you might want to examine the contents of internal 1802 registers or control the operation of a cassette recorder. As more features are needed,



ICIO,II=4016; PIN 7 OF IC9,10,11 =GND; PIN 14 OF IC9,10,11 = +5

Fig. 2. Eight low-cost, readily available 2102 RAM's (1024 x1) and two transmission gate packages.

you may want to dedicate the entire 256 bytes of memory in the basic system to your operating system and add another section of memory for your other programs. The 256-byte operating-system memory can be battery-powered and protected from modification by the MP switch so that it is always ready for use.

Memory Expansion. You can add 1024 bytes of memory to an Elf microcomputer using inexpensive, readily available 2102-type static RAM's as shown in Figs. 1 and 2. The 10k bus pull-up resistors are required if the high-output level of the RAM chips isn't at least 3 volts. Bits 0 and 1 of the high-order address byte are clocked into the address latch with TPA (Fig. 1). These two latched bits are used with the low-order COSMAC address byte to provide the required 10-bit address for the 2102 RAM's. Bit 2 of the high-order address byte is clocked into the address latch for use in selecting either the original 256-byte RAM or the added 1024-byte section of RAM. Disconnect pin 19 of the original two 2101 RAM chips from ground and connect to pin 12 of the 4042 address latch in Fig. 1.

The original 256-byte memory will now be addressed as 0000-00FF and the new 1024-byte memory will be addressed as 0400-07FF. Since all of the previous programs assumed one-byte addresses, they will *not* run in this expanded memory system. Programs for systems with more than 256 bytes of memory must have both the high-order and low-order bytes of address registers properly set. The previous programs can be easily modified to run in the expanded system by initializing both high- and low-order bytes of any 16-bit register used to address memory. The foregoing counting program could be modified to run at M(0000) in an expanded RAM system as shown in Program 5. In general, it adds only a few bytes to program for an expanded-memory system. By adding bits to the address latch of Fig. 1, you could address up to 64k bytes of RAM. Instead of addressing extra memory, the high-order address bits could be used to select input/output circuits or devices.

Don't forget that adding memory will increase system power requirements. As the system is expanded, make sure your external power supply can handle the increased current requirements. With this in mind, you'll find that the Elf can be tailored to your needs at low cost. ◇

A READER'S ELF PROGRAMS

I recently constructed the COSMAC Elf described in your August (1976) issue and thoroughly enjoyed the construction and testing of this microprocessor system. I build approximately two projects a month that are illustrated in your magazine—plus some from other sources. This particular project turned out to be the most interesting I have ever constructed. Here are three programs that I found useful in illustrating various system functions.

Program I is simply an expansion of your Q-light program with additional decisions that alternately turn the Q light on and off when the input switch is depressed.

Program II displays and increments successive hex characters each time the input button is depressed. To do this, it was necessary to learn how to input to and output from the memory, using pointers in registers, and also to do simple arithmetic through the accumulator (D register).

Program III plays SOS in Morse code. The program should be loaded through the system switch registers if you have a half hour without interruption. With this program, registers are used for pointers to subroutine loops set up for time delay. Three subroutines for 0.5 second, 1 second and 3 seconds are established, addressed by changing the program counter. The main program simply turns the Q light on and off at intervals determined by the subroutines. The memory provided in the basic Elf system (256 bytes) is enough for approximately 19 code elements. Each code element requires only 10 instructions for an on and off interval in the main program. The timing loops require the use of two registers to provide a sufficient time. In my Elf, I used a 1-MHz crystal. Obviously, changing one instruction in the loop subroutines will vary the time as necessary. Changing or adding to the main program can change the code.

Try loading this program with the switch register if you have enough patience.

—*Robert Klein*

```
              PROGRAM I

SWITCH ON AND OFF                3F
                                 ØØ
                                 37
                                 Ø2

IF Q OFF GO TO Ø9                39
                                 Ø9

IF Q ON, TURN OFF AND            7A
RETURN TO ØØ                     3Ø
                                 ØØ

IF Q OFF, TURN ON AND            7B
GO TO ØØ                         3Ø
                                 ØØ
```

```
              PROGRAM II

STORE DEPENDENT VARIABLE ØØ      E4
IN LOCATION 77 WITH POINTER      F8
IN R4--DESIGNATE R4 AS RX        77
                                 A4
                                 F8
                                 ØØ
                                 54

STORE INDEPENDENT VARIABLE Ø1    F8
IN LOCATION 76 WITH POINTER      76
IN R5                            A5
                                 F8
                                 Ø1 (size of INCR)
                                 55

DISPLAY AND DECREMENT RX         64
                                 24

LOOK FOR INPUT SWITCH ON AND     3F
OFF                              ØF
                                 37
                                 1Ø

ADD TWO VARIABLES AND PUT        Ø5
RESULT IN LOCATION 77            F4 (F5 subtract)
(can be changed to subtract      54
to count down)

RETURN TO START OF LOOP          3Ø
                                 Ø7
```

PROGRAM III

MAIN PROGRAM

```
INITIALIZE    F8
POINTERS      65 *
              A3
              F8
              79 *
              A4
              F8
              8D *
              A5

              7B
FIRST DOT     D3
              F8
              65 *
              A3
              7A
              D3
              F8
              65 *
              A3

              7B
              D3
              F8
SECOND DOT    65 *
              A3
              7A
              D3
              F8
              65 *
              A3
```

```
              7B
              D3
THIRD DOT     F8
              65 *
              A3
              7A
              D3
              F8
              65 *
              A3

              7B
FIRST DASH    D4
              F8
              79 *
              A4
              7A
              D3
              F8
              65 *
              A3

              7B
              D4
              F8
              79 *
              A4
SECOND DASH   7A
              D3
              F8
              65 *
              A3
```

```
              7B
              D4
              F8
              79 *
THIRD DASH    A4
              7A
              D3
              F8
              65 *
              A3

              7B
              D3
              F8
              65 *
FOURTH DOT    A3
              7A
              D3
              F8
              65 *
              A3
```

```
              7B
              D3
              F8
              65 *
FIFTH DOT     A3
              7A
              D3
              F8
              65 *
              A3

              7B
              D3
              F8
SIXTH DOT,    65 *
PAUSE AND     A3
RETURN TO     7A
START         D5
              F8
              8D *
              A5
              3Ø
              ØØ
```

* If a different number of code elements is used, change the starting address of each sub routine, or move to the end of memory page if flexibility is desired.

PROGRAM III

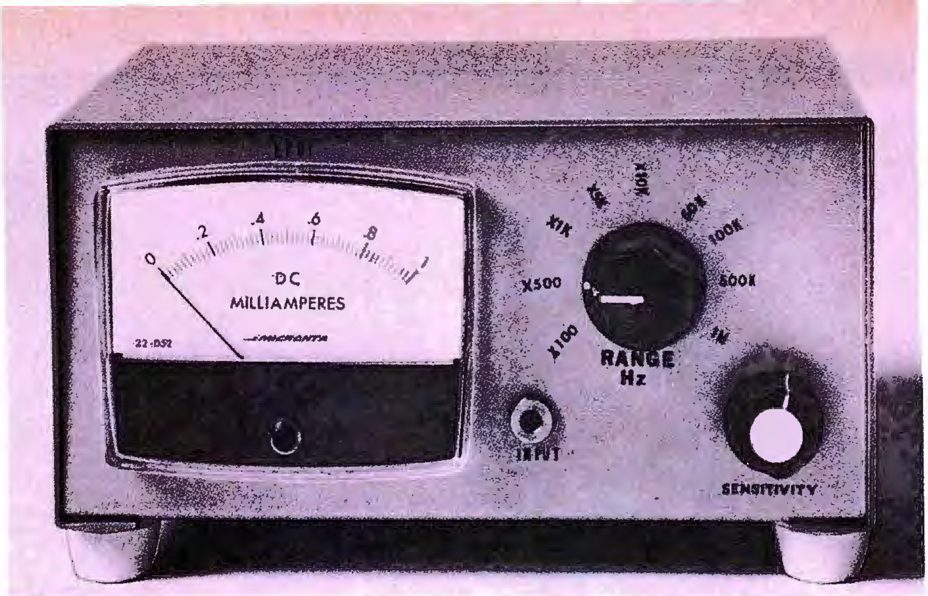
SUB ROUTINES (Must be loaded in order indicated after main program is loaded.)

All instructions same as ½-Sec Loop except where indicated

	½-Sec Loop	1-Sec Loop	3-Sec Loop
PUT 256 IN REG #1	F8	.	.
	FF	.	.
	A1	.	.
PUT VARIABLE INTO REG #2	F8	.	.
	08 *	ØF *	3Ø *
	A2	.	.
DECREMENT AND LOOP THRU R1 UNTIL ZERO. THEN OUTPUT TO DECREMENT REG #2	C4	.	.
	C4	.	.
	C4	.	.
	C4	.	.
	C4	.	.
	21	.	.
	81	.	.
	3A	.	.
	6B **	7F **	93 **
LOOP BACK TO START R #1 CYCLE UNTIL TOTAL TIME IS USED UP	22	.	.
	82	.	.
	3A	.	.
	6B **	7F **	93 **
RETURN TO MAIN PROGRAM	DØ	.	.

* Sets Time

** If a different number of code elements is used, change this instruction to starting address of each subroutine wait loop (first C4)



Uses readily available components and an analog readout.

BY JOHN F. HOLLABAUGH

Build A 10-Hz To 1-MHz EPUT Meter

THE EPUT (*E*vents *P*er *U*nit *T*ime) meter is an inexpensive frequency counter that can measure sinusoidal and complex waveforms over a range from 10 Hz to 1 MHz. It uses inexpensive TTL logic, a FET front end, and an analog readout. Accuracy is quite good, as the 60-Hz power-line frequency is used as a calibration reference. A trigger sensitivity control is included to set the input signal threshold. The front end has a resistive input impedance of 100,000 ohms. A 1.5-millivolt (minimum) input will result in a stable EPUT reading.

About the Circuit. The schematic diagram of the EPUT meter is shown in Fig. 1, with circuit details for the input amplifier, counting stages, and power supply shown in Figs. 2A, 2B, and 2C, respectively. A portion of the input signal is taken from the wiper of *R1*, the SENSITIVITY control, and applied to the gate of *Q1*, an n-channel FET, which functions as a source follower. Voltage gain is provided by the bipolar transistor *Q2*. This transistor boosts the input signal to a

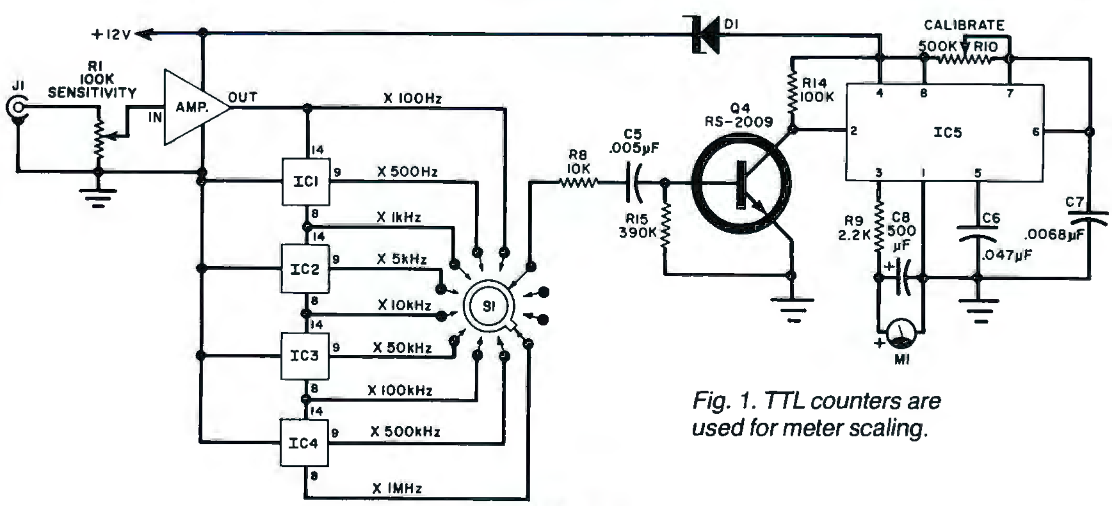


Fig. 1. TTL counters are used for meter scaling.

PARTS LIST

C1, C3, C6—0.047-µF, 50-V Mylar capacitor
C2—10-µF, 15-V electrolytic capacitor
C4—22-µF, 15-V electrolytic capacitor
C5—0.005-µF disc ceramic capacitor
C7—0.0068-µF disc ceramic capacitor
C8—500-µF, 15-V electrolytic capacitor
C9—1000-µF, 35-V electrolytic capacitor
D1—4-V, ½-W zener diode
IC1-IC4—7490 decade counter
IC5—555 timer
IC6—LM309 5-volt regulator
J1—RCA phono jack
M1—0-to-1-mA meter (Radio Shack 22-052 or equivalent)
Q1—N-channel FET (Radio Shack RS-2028 or equivalent)
Q2-Q4—npn silicon switching transistor (Radio Shack RS-2009 or equivalent)
All fixed resistors are ½-watt, 10% tolerance:
R1—100,000-ohm linear taper potentiometer
R2—150,000 ohms
R3,R5,R7,R9—2200 ohms
R4,R6—220,000 ohms
R8—110,000 ohms
R10—500,000-ohm linear taper potentiometer (screwdriver adjust)
R11, R13—1 megohm
R12—3300 ohms
R14—100,000 ohms
R15—390,000 ohms
S1—1-pole, 12-position nonshorting rotary switch (Lafayette 30 R 40144 or equivalent)
S2—SPST toggle switch
T1—12-V, 500-mA transformer
Misc.—Hookup wire, suitable enclosure, IC sockets or Molex Soldercons (if desired), printed circuit or perforated board, ¼-inch spacers, machine hardware, solder, etc.

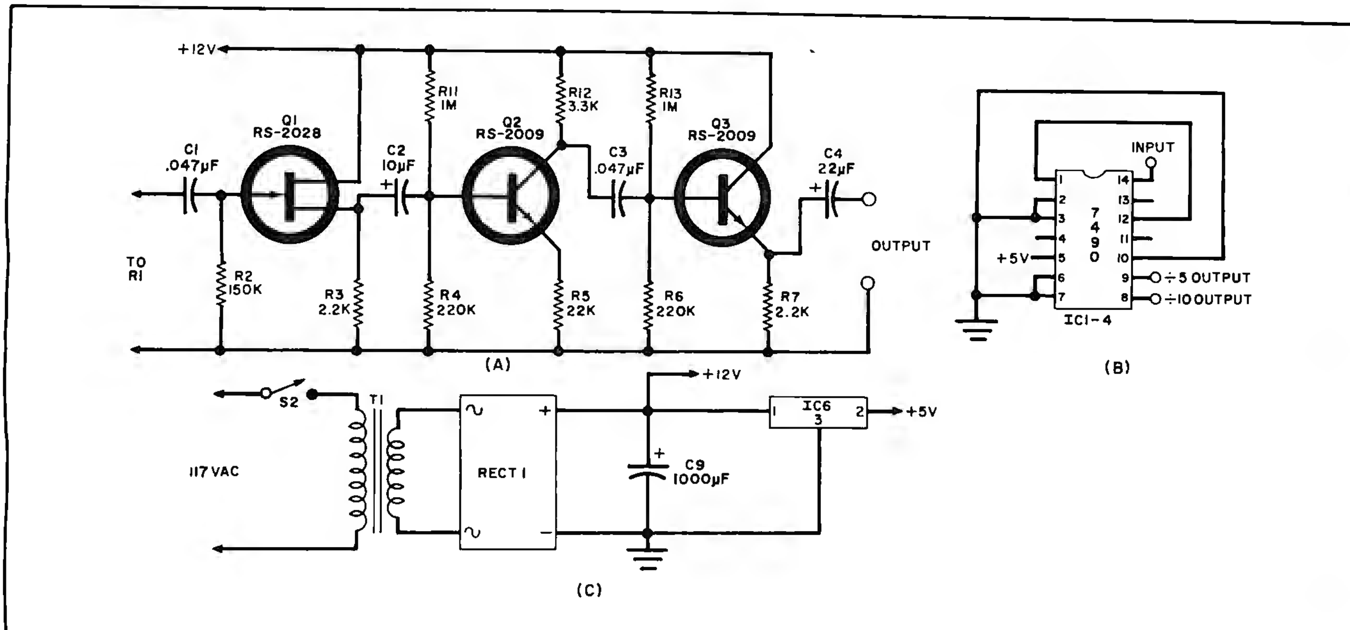


Fig. 2. Circuit details are shown for the input amplifier at (A), for the biquinary counters at (B), and for the power supply at (C).

level exceeding the 2-volt, logic-one threshold of the TTL counter inputs. The current required to drive counter *IC1* is furnished by *Q3*, an emitter follower.

Biquinary counters *IC1* through *IC4*, each of which comprises four flip-flops and an AND gate, provides outputs whose frequencies are one-fifth and one-tenth that of the input. These are used for range expansion of the analog meter, whose associated circuitry measures frequencies from zero to 100 Hz only. The 0-to-1-mA meter is connected to the output of *IC5*, a 555 timer operating in the one-shot mode. The average value of the pulse output is directly proportional to the number of pulses occurring each second, and this rate is governed by the frequency of the signal that triggers *IC5*.

The trigger signal, which is provided by the amplifier in the direct (*X 100 Hz*) mode, and by the outputs of the counters on the higher ranges, is inverted by *Q4* to make the negative-edge triggering of *IC5* compatible with the positive-edge triggering of the TTL counters. The width of the pulse output of *IC5* is determined by the setting of *R10*. This is the only calibration adjustment required, because the meter circuit always works with signals below 100 Hz. Switch *S1* selects which signal will trigger the 555.

To eliminate the need for an expensive meter with good dynamic damping, electrolytic capacitor *C8* is connected across the meter. This provides stable readings down to 10 Hz. Without the capacitor, the meter specified vibrates very severely below 20 Hz.

Construction. Because the EPUT circuit is fairly simple, it can be assembled on a printed circuit or perforated board. The use of an LM309 voltage regulator (*IC6*) is strongly recommended, because 7490's are very intolerant of even brief overvoltages. Try to keep the board layout clean, and by all means use the minimum amount of heat and solder necessary for good, *clean* connections. Integrated circuits can be soldered directly to the circuit board, or if desired, IC sockets or Molex Soldercons can be used. Use a metal utility box as an enclosure. A 6″ × 4½″ × 3″ (15.2 × 11.4 × 7.6 cm) utility box provides ample space for all components. Bolt the regulator IC to the enclosure using ¼-inch (6.4-mm) spacers. This is done to provide a good heat sink and to ground the case of the integrated circuit.

Calibration. Connect a source of low-voltage, 60-Hz ac to input jack *J1* using a length of shielded or small coaxial cable. A 6.3-volt filament transformer makes a fine signal source. Higher voltages can be used, but don't exceed 12 volts *peak* at this or any other time. Use a resistive voltage divider, if necessary, to attenuate the input signal. With RANGE switch *S1* in the "*X 100 Hz*" position, advance SENSITIVITY control *R1* until a reading is obtained on the meter. Then adjust *R10*, the CALIBRATE control, for a reading of 0.6 mA on the meter. This corresponds to a reading of 60 Hz (0.6 × 100 Hz). This is the only calibration adjustment necessary. Of course, you can check for proper counter operation with a 100-kHz or 1-MHz frequency standard.

Operation. You can use the EPUT meter to measure complex waveforms or sine waves up to a frequency of 1 MHz. Just be sure that you don't exceed 12 volts peak input. Use shielded cable for the input signal to minimize noise pickup. If you want to measure an unknown frequency, start with *S1* in one of its higher ranges. Adjust *R1* until you get some needle movement in *M1*. If the needle stays at the lower end of the scale, go to a lower position of the RANGE switch until a usable reading is obtained. ◇

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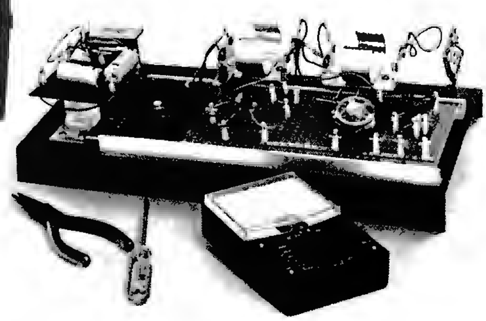

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CLASSES of AUDIO AMPLIFIERS

What the various types mean to today's audiophile.

BY LEN FELDMAN

Manufacturers of high-fidelity audio amplifiers like to stress the type of circuit—class A, B, C, D, or G—used in their latest products. Let's take a look at what all these various types are and why some of them have taken on special meaning in recent years. Despite the fact that class-B amplifiers are by far the most widely used, we'll start at the beginning of the alphabet.

Class-A Amplifiers. Amplifiers are grouped in classes primarily on the basis of the period of conduction of a given amplifying device. In a class-A amplifier, a single output transistor conducts current continuously. An audio signal applied to the amplifier stage (Fig. 1A) varies the amount of current in the output according to the transfer characteristic shown in Fig. 1B. Quiescent current I_c flowing through the transistor in the absence of an audio signal must be great enough so that even during negative half-cycles of the audio waveform, the output is not cut off completely. Thus the output waveform is a more or less exact replica of the input.

The chief disadvantage of the class-A amplifier is its inefficiency. Since average current flow is the same whether or not a signal is applied to the input, class-A amplifiers have an overall efficiency of between 20% and 30%. Only about 25% of the energy applied to the transistor gets converted into useful output power. The rest of the energy must be dissipated as heat, within the transistor itself or into a heat sink to which the transistor is thermally coupled. Class-A amplifier stages are frequently used in low-powered products. Since these products are generally designed to produce only a fraction of a watt of audio output, the poor efficiency of class-A operation is not a problem. Recently, the advantage of the extreme linearity of the class-A circuit has prompted some hi-fi amplifier manufacturers to resort to this mode of operation even in higher-powered audio amplifiers. Such designs, however, have necessitated the use of extremely large heat sinks and oversize power supplies.

Class B. In the class-B audio amplifier, each of two transistors is biased very nearly to cutoff, as shown by the transfer characteristic of Fig. 2B. Since a single transistor now conducts during only half the applied signal, two transistors must be used to reproduce the entire waveform—each arranged to handle one alternation of the waveform. One way of doing this is to use the transformer-coupled push-pull transistor stage in Fig. 2A. Here, the waveform applied to the base of Q2 has a polarity that is the opposite of that applied to the base of Q1. Each transistor, therefore, conducts during opposite halves of the signal waveform's excursions. The two halves of the amplified waveform are combined in the primary winding of T2, the secondary of which feeds the speaker load. Transformer T2 is easily eliminated by using a complementary pair of output (matched npn and pnp) transistors so that each handles half the input signal waveform. A capacitor-coupled output stage is shown in Fig. 3A, while Fig. 3B shows how, by means of positive and negative power supplies, the output capacitor can

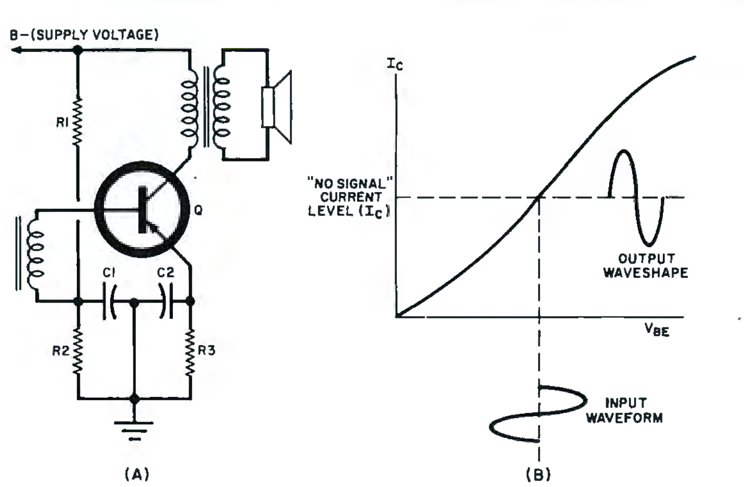


Fig. 1. At (A) is typical class-A circuit. Transfer characteristic (B) shows how stage is biased into heavy conduction.

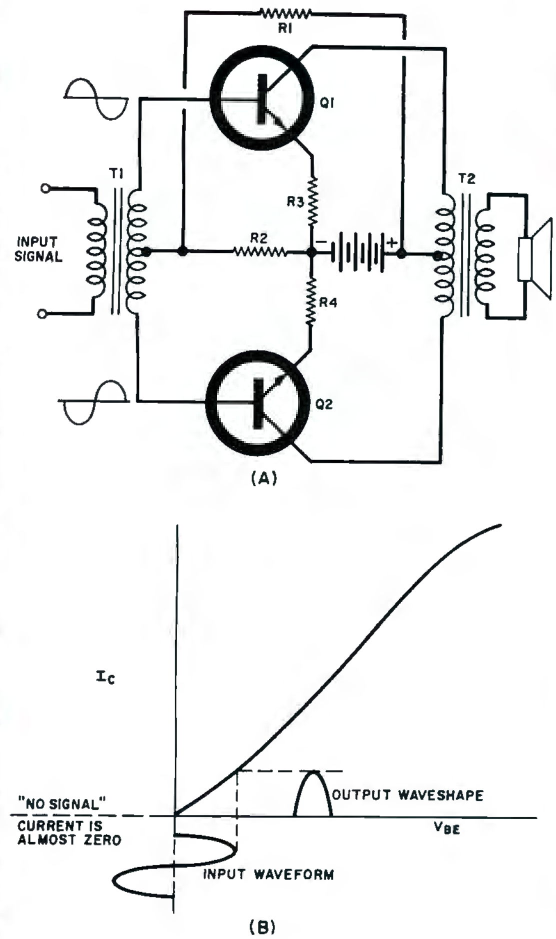


Fig. 2. Circuit (A) and transfer characteristic (B) for class-B amplifier, biased near cutoff.

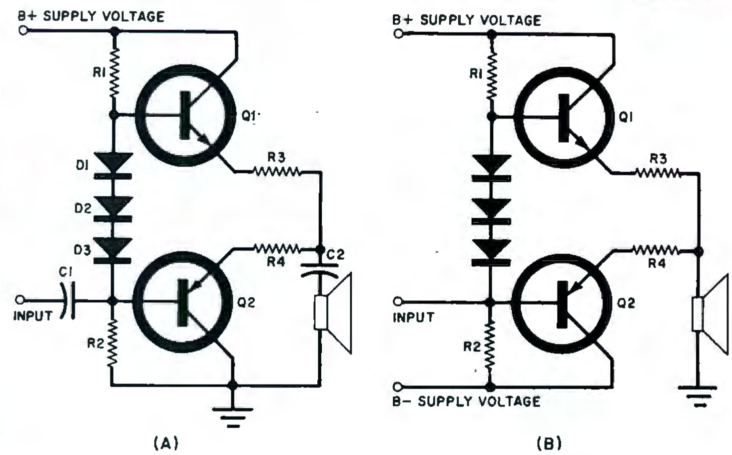


Fig. 3. Complementary npn-pnp class-B circuit, capacitor-coupled (A) and direct-coupled (B).

be eliminated to produce the popular "direct-coupled" output stage featured in most currently produced solid-state hi-fi amplifiers.

The great advantage of class-B operation is higher efficiency than in class-A amplifiers. In typical class-B circuits the efficiency can range as high as 65%. The chief disadvantage of this circuit lies in the fact that the transition between conduction of one transistor and the other may be less than perfect. If one transistor stops conducting just a bit before the other begins to conduct, the output waveform may contain a discontinuity, which is generally referred to as "notch distortion" or "crossover distortion." This condition is illustrated in Fig. 4. Unlike overload or clipping distortion, which occurs only when an amplifier is driven beyond its rated power output, notch distortion can occur at all listening levels. In fact, it is more bothersome at low output levels, where it constitutes a greater percentage of the total output. In addition, notch distortion generally produces higher order harmonics (seventh, ninth, etc.) that are usually more audibly annoying than equivalent percentages of second- and third-harmonic distortion most commonly associated with "clipping" or overload conditions in an audio amplifier.

Class AB. This type of operation falls midway between classes A and B. While neither of the two transistors in a class-AB output stage conducts over the full audio input signal waveform, each continues to conduct for more than a half-cycle. The operating point for a transistor biased for class AB operation is shown in Fig. 5. In class-AB circuits, notch distortion is eliminated because, during the critical transition from positive to negative polarity of the input signal waveform, both output transistors are conducting. The efficiency of a class-AB circuit is also somewhere between that of classes A and B circuits.

Class C. In the class-C amplifier, conduction occurs over less than half a waveform cycle, as illustrated in the transfer diagram of Fig. 6. Class-C amplifiers are not used in audio applications because there is no way for such an amplifier to follow the complex waveform shapes of an audio signal. Rather, class-C amplifiers find application in radio-frequency (r-f) amplification, where a single frequency is to be amplified. Resonant LC (inductive-capacitive) circuits incorporated at the input and output sides of a class-C amplifier provide a so-called "flywheel" or "pendulum" effect that recreates the "missing" portion of each cycle of the input waveform. In effect, energy is supplied to the associated resonant circuits for a short period during each alternation in much the same way that a light tap applied to the

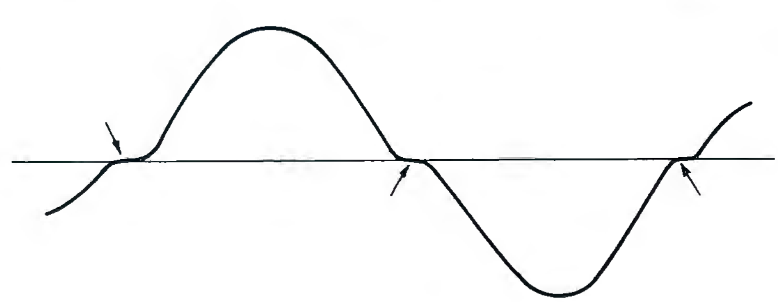


Fig. 4. Extreme example of notch distortion possible with poorly designed class B output circuits.

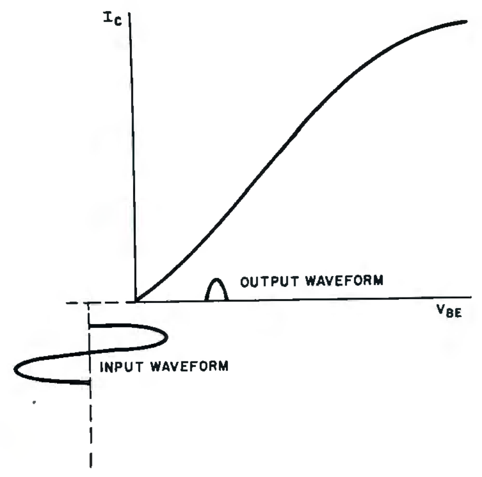


Fig. 5. Class AB requires two transistors in push-pull, operates between class A and B.

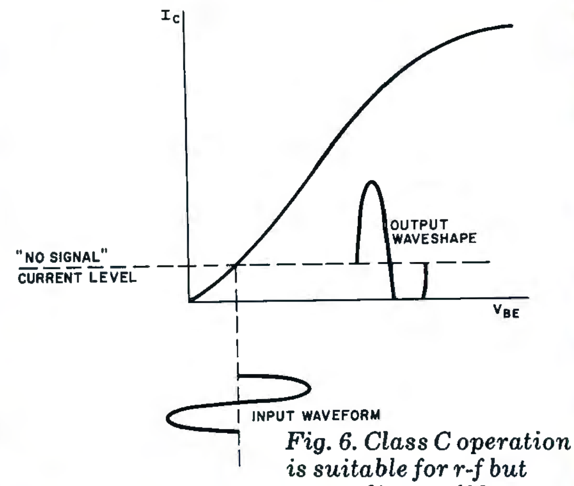


Fig. 6. Class C operation is suitable for r-f but not audio amplifiers.

lower portion of a swinging pendulum every time the pendulum reaches one end of its swing can keep it swinging over a wide arc. The efficiency of a class-C amplifier is high—between 65% and 85%—since the amplifying stage itself is called upon to conduct for a very short portion of the waveform cycle.

Class D. So-called class-D circuits have been used in military and high-power applications for some time. In audio applications, class-D circuitry is new. Instead of using transistors as linear amplifiers (as is the case for all the other classes of amplifiers we have discussed so far), the transistor is used as a switch. Audio input signals are first converted to pulses of varying widths. These pulses switch the transistors on and off at a super-audible high-frequency rate (as high as 500,000 times per second). By having the audio signal control when the transistor switches high voltages and currents, the signal is amplified. The output pulses are "summed" or integrated by a filter or smoothing network to produce an output signal that resembles the input audio waveforms.

Switching amplifiers can and do run at efficiencies of greater than 95%. Infinity Systems, Inc. introduced the first such amplifiers. The high efficiency of the amplifier drastically reduces heat-sink requirements and makes for a very compact amplifier package. The Infinity Systems amplifier is said to be capable of delivering continuous 250 watts per channel under any line conditions from 96 to 240 volts while remaining cool. At $1850, the class D amplifier is expensive, but if it proves its claims, we are likely to see more versions designed for audio applications from a number of manufacturers in the future.

Class G. We have not inadvertently skipped "classes E and F." In fact, when Hitachi first developed its high-efficiency circuit, the company had called it class E. Later, it was discovered that there already existed amplifier configurations that had been assigned the designations class E and class F. Accordingly, Hitachi elected to call its high-efficiency amplification scheme class G, though in some of the literature you may find that the system is still referred to as a Series E audio amplifier.

In a class-G amplifier, double pairs of output transistors are used in push-pull operation (Fig. 7). When the input voltage is lower than V1 (or V1′), Q2 and Q2′ are cut off and current flows through Q1 and Q1′ to the load. Once the input voltage exceeds V2, the current to the load is through Q2-Q1 and Q2′-Q1′. For music reproduction, the amplifier operates most of the time with V1 and V1′ (more than 90%) and a very small fraction of the time from V2 and V2′. Power dissipation is thus low.

Crossover distortion from V1 to V2 and vice versa is minimized by using high-speed transistors and diodes. Residual switching spikes or instantaneous signal dropout are minimized by circuit design techniques.

Although the efficiency of a class-B amplifier can be as high as 65%, it should be understood that this level is reached only when the amplifier is delivering its rated output. At all lower levels, efficiency is considerably less. For the class-G circuit, since each transistor is operating closer to its optimum efficiency point more of the time, the overall efficiency of the system is improved to about 75% or 80% for much of the time that conduction of audio signals actually occurs.

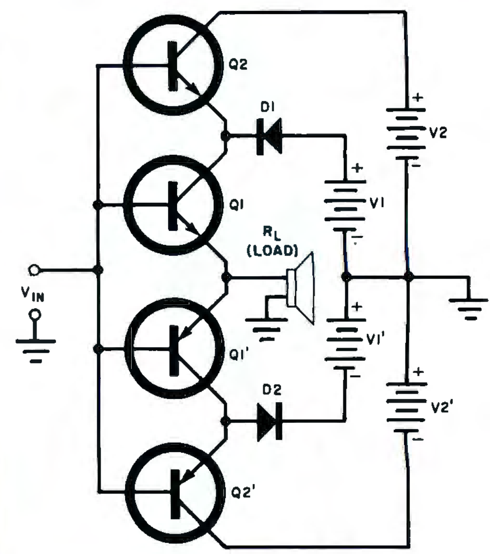
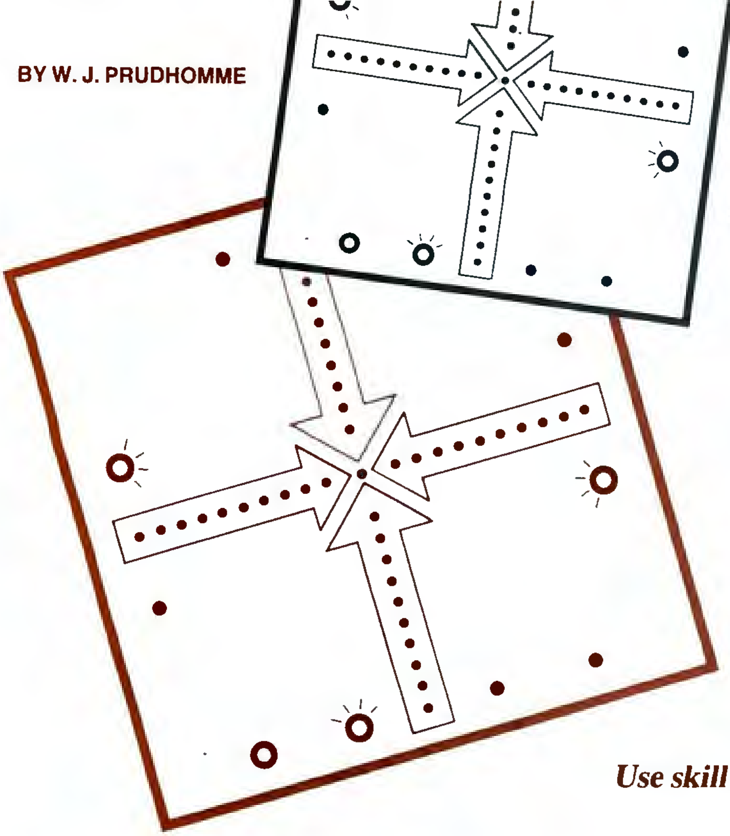


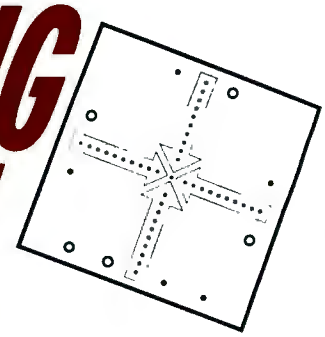
Fig. 7. Simplified diagram of class G amplifier stages.

Summing Up. It should be clear from this brief analysis of the various amplifier classes that each has its advantages and disadvantages. Manufacturer's claims notwithstanding, to say that a class-A amplifier is inherently better than a class-B amplifier or that a class-D switching amplifier is better than a class-G amplifier is an oversimplification at best. Since all classes of amplifiers are currently used in modern amplifier designs, we must conclude that the choice of class involves a series of trade-offs and that properly executed designs in each amplifier class can result in high-fidelity audio amplifiers that come close to faithful reproduction of sound. And faithful reproduction of sound is, after all, the end goal of all hi-fi products. ◇

BY W. J. PRUDHOMME



MULTIPLAYER LED RACING GAME



Use skill as well as chance to win the game of "Strategy."

MOST electronic games, like dice and roulette, depend purely on luck. The "Strategy" game presented here, however, depends on the player's skill and the strategic maneuvers one exercises to win. Each of up to four players tries to get "home" before the others. A player can move directly toward home, a step at a time, or use strategy to move an opponent backward, while sacrificing a chance to move forward. In either case, a relative degree of skill is required, the amount of skill determined by a variable-rate blinking LED.

Directly in front of each player's position on an 18" (45.7-cm) square playing field is a set of 10 LED's arranged inside a colored arrow that points toward the center of the field. At the center of the field is a master LED that blinks at an adjustable rate. As each player's turn comes up, he tries to score and move one step closer to the point of his arrow by pressing his SCORE pushbutton switch. Here is where the skill comes in because the SCORE button must be pressed at the exact instant the master LED flashes on. If the SCORE button is pressed too soon or too late, the player fails to score. Since the SCORE button generates only a short pulse when it is operated, timing is very critical. Holding down a SCORE button will be ineffective because this pulse is generated only when the button is initially pressed. Changing the flash rate of the master LED determines the level of difficulty in playing the game.

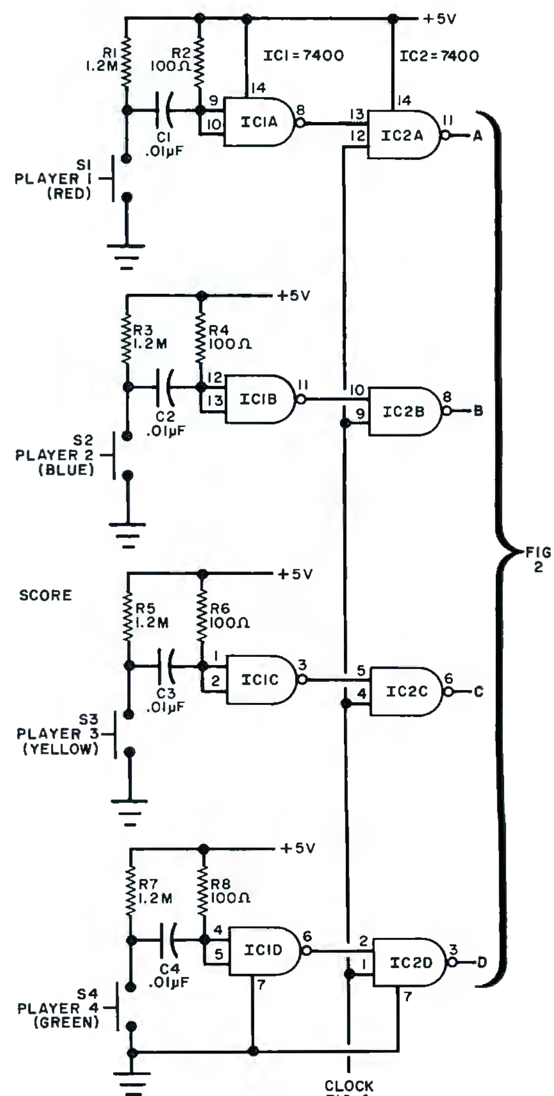


Fig. 1. Each time a player's pushbutton is operated, a single pulse is generated by its IC1.

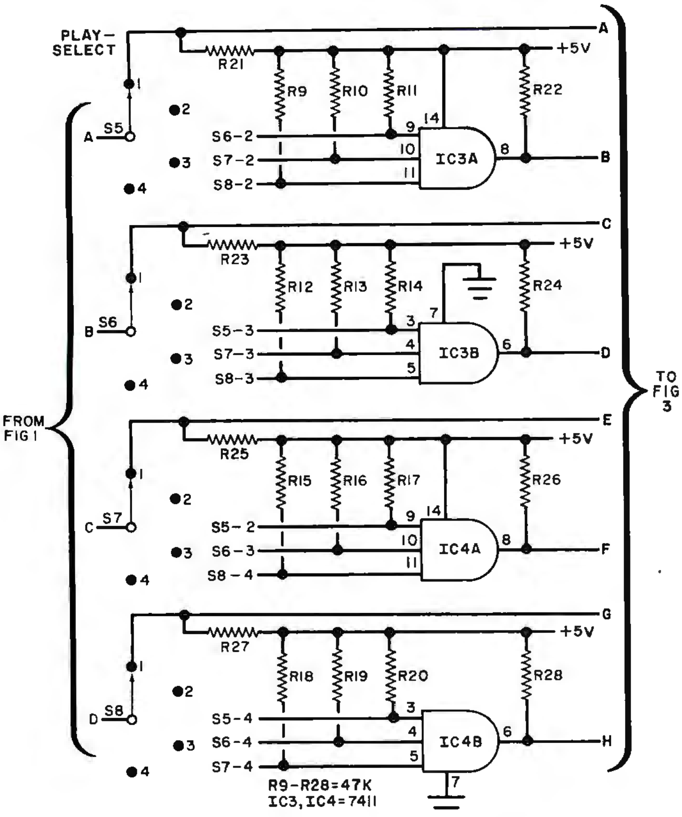


Fig. 2. Pulses are applied to player's LED or opponent's.

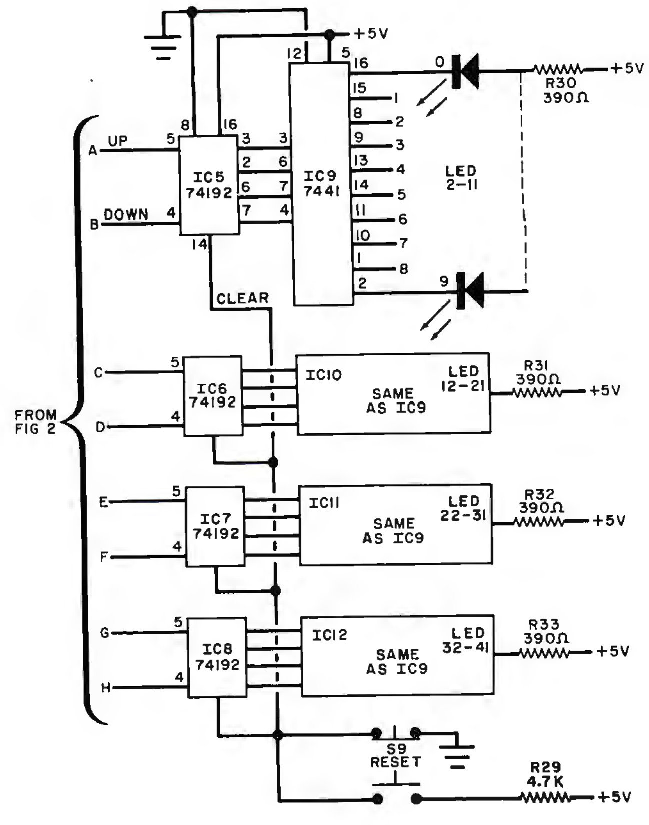


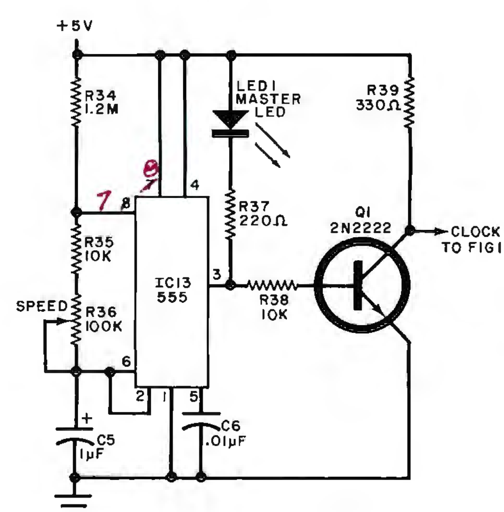
Fig. 3. Each counter drives its decoder to turn on LED's.

PARTS LIST

C1,C2,C3,C4,C6,C8—0.01-μF disc capacitor
C5—1-μF, 15-V electrolytic capacitor
C7—1000-μF, 25-V electrolytic capacitor
C9—1-μF, 15-V nonpolarized capacitor
D1 through D4—1N4002 rectifier diode
F1—½-ampere standard fuse
IC1,IC2—7400 quad 2-input NAND gate
IC3,IC4—7411 triple 3-input NAND gate
IC5 through IC8—74192 up/down decade counter
IC9 through IC12—7441 one-of-10 decoder/driver (see text)
IC13—555 timer
IC14—LM309K 5-volt regulator
Q1,Q2—2N2222 transistor
Q3—Programmable unijunction transistor (Radio Shack No. 276-119 or similar)
The following resistors ½-watt, 10%
R1,R3,R5,R7,R34—1.2 megohms
R2,R4,R6,R8—100 ohms
R9 through R29,R40—4700 ohms
R30 through R33—390 ohms
R35,R38—10,000 ohms
R37—220 ohms
R39—330 ohms
R41—22,000 ohms
R43—27,000 ohms
R44—56,000 ohms
R36—100,000-ohm potentiometer with spst switch
R42—10,000-ohm potentiometer
S1 through S4—Spst normally open pushbutton switch
S5 through S8—Single-pole, four-position nonshorting rotary switch
S9—Momentary-action pushbutton switch with one set each normally open and normally closed contacts
S10—Spst switch (part of R36)
SPKR—8-ohm miniature speaker
T1—6.3-volt, 1.5-ampere transformer
Misc.—Two 19½" lengths of 1" × 3" pine for frame sides; two 18" lengths of 1" × 3" pine for frame sides; two 18" lengths of 1" × 2" pine for cleats; two 16½" lengths of 1" × 2" pine for cleats; one 18"-square piece of ¼" plywood or Masonite for playing field; one 18"-square piece of ¼"-thick Masonite pegboard for bottom plate; fuse holder; printed circuit or perforated board; IC and transistor sockets (optional); paint; sandpaper; line cord; rubber feet (4); white glue; finishing nails; woodscrews (1" long); control knobs (4); hookup wire; solder; etc.

In addition to being able to adjust the difficulty of play with the TIMING control, each player has a PLAY/SELECT switch that he can use to attempt to prevent his opponents from scoring. With this switch, a player can elect to advance his own position on the board or cause an opponent to retreat one step. The latter strategy is useful when an opponent is getting too close to home and a player is willing to sacrifice his own advancement to send him back.

Fig. 4. The 555 operates at about 1 Hz, but its duty cycle can be varied by control R36.



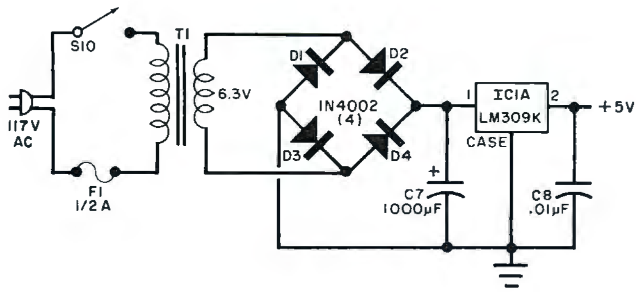
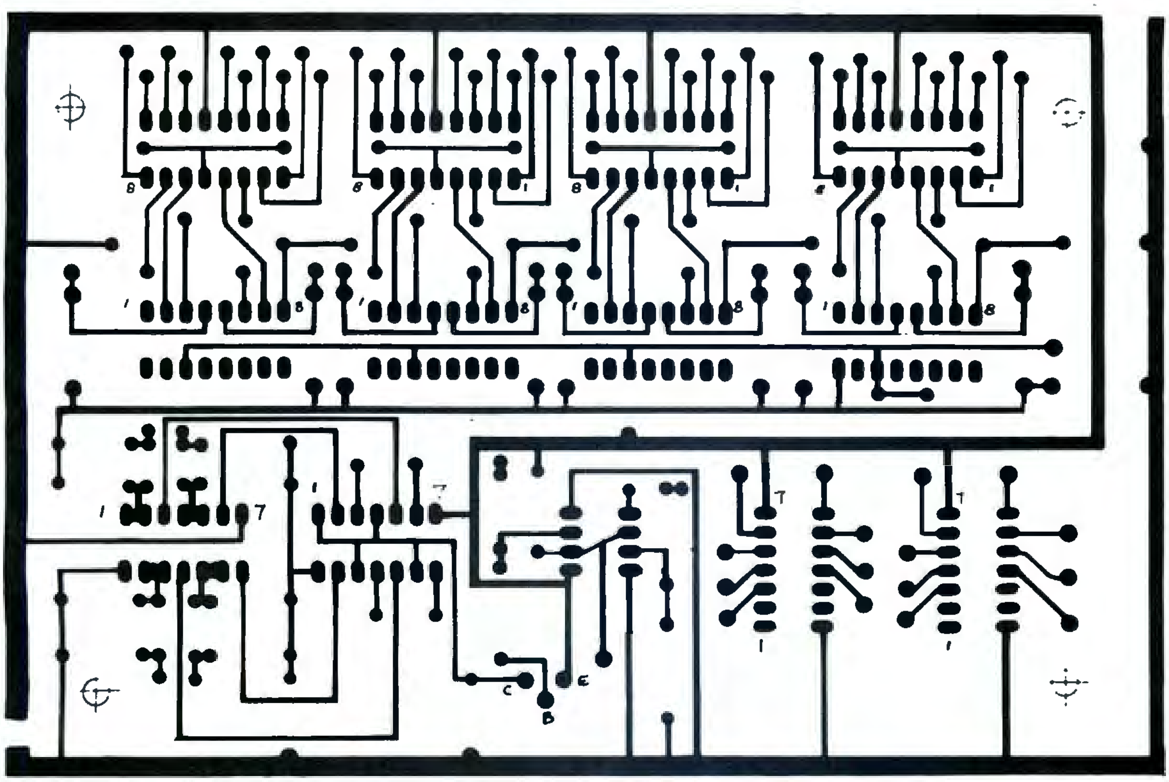


Fig. 5. Power supply is conventional regulated 5-volt system.

About the Circuit. The complete schematic diagram of this game is shown in Fig. 1 through Fig. 4, while the power supply common to all circuits is shown schematically in Fig. 5. Starting with Fig. 1, when a player presses his SCORE button (*S1*, *S2*, *S3*, or *S4*), the inputs of the appropriate NAND gate in *IC1* are grounded by the capacitor (*C1*, *C2*, *C3*, or *C4*). Since the inputs to the NAND gate are also connected to the common +5-volt line through separate 100-ohm resistors, the capacitor quickly charges, returning the output of the gate to its original low state. When the SCORE



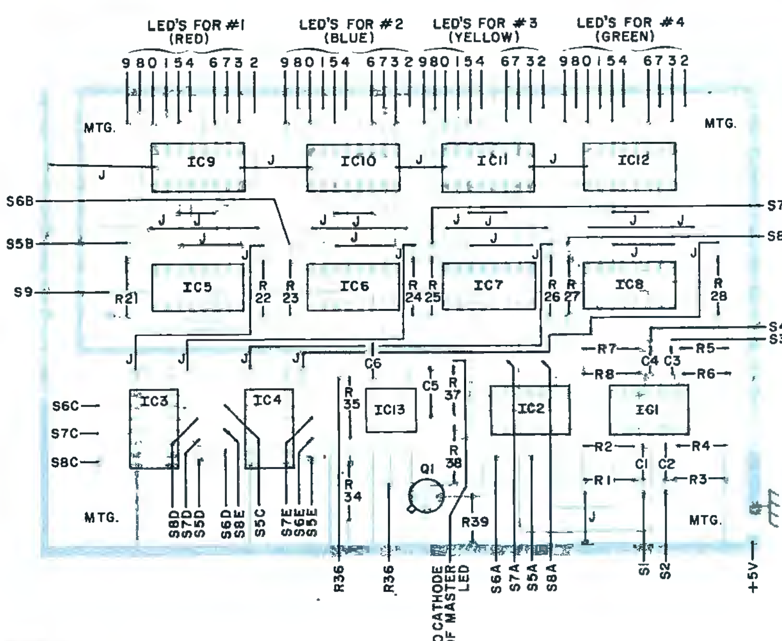


Fig. 6. Actual-size etching and drilling guide is shown above with component layout at left. External connections are also shown at left.

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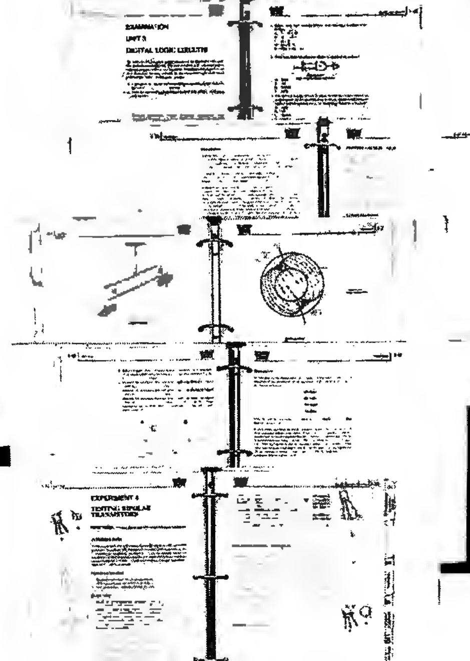

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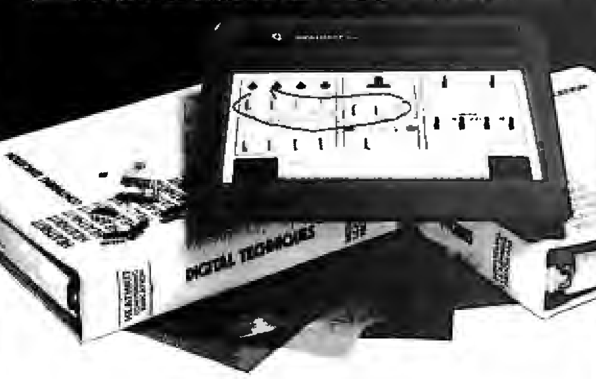

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GAME RULES

1—Rotate SPEED control clockwise to turn on power and adjust level of game difficulty.
2—Press and release RESET switch.
3—Choose (by lot, with dice, or by cutting cards) starting player.
4—First player begins by setting his PLAY/SELECT switch to his own color and trying to press his SCORE button at exact instant master LED turns on.
5—If a player is successful in scoring a point, his LED will advance one step. Whether or not the first player scores, next play goes to the next player in a clockwise direction around the board.
6—When an opponent gets near the finish line, it is possible for any other player to move him back one step by setting his PLAY/SELECT switch to the other player's color and operating his SCORE button. The same odds apply whether a player wishes to advance his own score or send another player back one step. A player who elects to send an opponent back forfeits his chance to score.
7—First player to reach home is the winner. If desired, the game can be played to determine the second- and third-place winners.
8—Players can mutually agree to change the rules to add variety to the game. For example, instead of one play at a time, each player can be allowed to score as many points as possible in a given period of time. Another possibility is to allow each player two scoring attempts per turn. In this case, he can elect to score twice, move one or two opponents back, or move one player back and also score.

button is released, the output remains low and the capacitor discharges through the 1.2-megohm resistor until the circuit is again ready to generate a pulse. The RC charge/discharge time, consequently, becomes an effective debounce circuit.

The output from the *IC1* NAND gate is coupled to one input of NAND gate *IC2*, where it is combined with the output pulse from the clock generator (Fig. 4). These gates determine if the player "scores" by detecting simultaneous inputs to the *IC2* gate. The logic rules for a two-input NAND gate require that if either input is low, the output will be high. Also, if both inputs are high, the output will be low. Hence, if the positive-going pulse generated by operation of the SCORE button and the positive-going clock pulse are present at the same instant, the output of that particular gate in *IC2* will go low for the duration of the pulse-coincidence interval. If the two pulses do not occur simultaneously, the output of the *IC2* gate will remain high, as it does between plays, and the player will not score.

When each player has taken his turn, the next player has the option of either advancing his own position or sending his opponent's position back one step. He does this by setting his PLAY/SELECT switch (*S5* through *S8* in Fig. 2). This circuit routes the player's pulse to the up-count input of his own counter (*IC5, IC6, IC7,* or *IC8* in Fig. 3) or to the down-count input of the opponent's counter selected by the PLAY/SELECT switch.

The up/down counters shown in Fig. 3 will advance one count for each low-to-high transition of the up-count input when the down-count input is held high and the clear input is held low, the latter via *S9* in Fig. 3. Conversely, the counter will back up one count for each high-to-low transition at the down-count input when the up-count input is held high and the clear input is held low. At the end of each game, *S9* must be pressed mo-

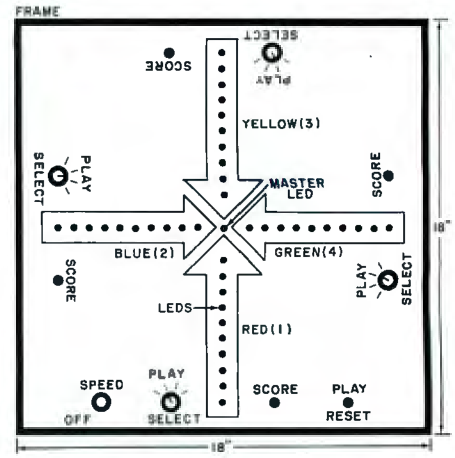


Fig. 7. Diagram shows layout of top of prototype game. Arrows are color-coded on 18" frame.

mentarily to reset the system for a new game.

The BCD output of each up/down counter is decoded by a 1-of-10 decoder (*IC9* through *IC12* in Fig. 3), with each of the 10 outputs connected to its own LED. Hence, there are 10 LED's for each player, all of which are driven by their own decoder. Only one LED at a time is on at any given time for each player. The glowing LED determines the player's position during the game. As the player advances position, the next LED toward the point of his arrow comes on and the position vacated extinguishes. Needless to say, the player who reaches the point of his arrow first is the winner of the game. Because only one LED for each player is on at any given time, only one current-limiting resistor (*R30* through *R33*) is required for each player position. The absolute maximum current output of the decoder specified in the Parts List is 10 mA. If you choose LED's that require more current, substitute 7445 IC's in place of the 7441's specified. The 7445's are capable of delivering up to 80 mA per output.

The clock circuit shown in Fig. 4 contains a 555 timer-IC oscillator whose time constant is approximately one pulse/second. Adjustment of potentiometer *R36* determines the on time of master indicator *LED1*. With the component values specified, the on time of the LED can be varied from about 0.01 to 0.1 second. This particular time span was selected because most people have a reflex action time of 0.3 second or longer. The intent here is that a player will not be able to wait for *LED1* to flash and then try to score by operating his SCORE switch. To be successful in scoring, a player must anticipate the flash. For this

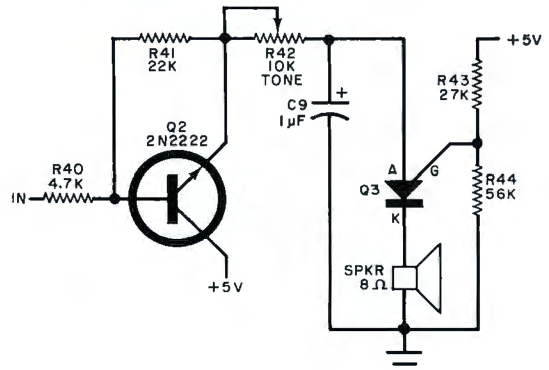


Fig. 8. Optional tone control can be connected to different portions of circuit (experimentally) to make the desired sound effect.

reason, the game challenges a person's timing skill, rather than his reflexes.

Transistor *Q1* is used as an inverter and TTL level converter. The power supply shown in Fig. 5 employs full-wave bridge rectification of the stepped-down ac and a 5-volt IC regulator.

Construction. Except for the LED's, switches, and power supply, the complete circuit can be assembled on a single printed circuit board. The etching and drilling and component-placement guides for the pc board are shown in Fig. 6. To conserve space on the pc board, pull-up resistors *R9* through *R20* mount directly on PLAY/SELECT switches *S5* through *S8*.

The playing field should be mounted in a frame that leaves enough depth under the field to accommodate the circuit board assembly and power supply. If you have a miter box, you can construct the frame with miter joints, in which case use four 19½" (49.5-cm) long pieces of 1" × 3" (25.4 × 76.2-mm) pine. Otherwise, simple butt joints will serve just as well. Fasten the joints together with finishing nails and white glue.

Glue and nail the 1" × 2" (25.4 × 50.8-mm) pine to the inner walls of the frame, spacing it ⅜" to ½" (9.5 to 12.7 mm) from the top edge of the frame. This will provide a convenient platform on which to mount the playing field board. Smoothly sand and paint or varnish the frame, making sure you do not paint or varnish the inside cleat.

Smoothly sand and paint the top surface of the playing field board white. When the paint has completely dried, drill the LED and control holes as illustrated in Fig. 7. Then paint on the color coded arrows. Apply a liberal bead of white glue to the upper surfaces of the cleats and lower the playing field board into place. Weight down the board with a few books until the glue has set.

Mount the LED's in the playing field's holes, using small dots of glue to hold them in place. Then mount the four SCORE, four PLAY/SELECT, and single SPEED controls in their respective locations. The main circuit board and power supply can be mounted on the peg board used as the bottom plate of the project. Route the line cord through one of the holes on the pegboard, after first enlarging it. Secure the bottom plate to the frame with eight woodscrews. Finally attach rubber feet to the frame.

Sound Effects. If you want sound effects with your game, you can use the experimental circuit shown in Fig. 8. This circuit employs driver transistor *Q2* to trigger programmable unijunction transistor *Q3*. It can be connected to various points in the main circuit, such as the master LED, to produce an audible "beep" when the LED flashes.

You can try wiring a 555 into the circuit to serve as an oscillator that produces various sounds. As an example, you can set the sound-effect system to produce a low-pitched tone for an unsuccessful scoring attempt and a high-pitched tone for a successful attempt. ◇

Solid State

By Lou Garner

TACHOMETER-SPEED SWITCHES

LAST November, you may recall, we discussed a number of lesser known semiconductor devices which we dubbed *rara avises*—rare birds. This month, let's take another visit to the rare-bird house and examine a family of interesting special-purpose IC's introduced recently by the *National Semiconductor Corporation* (2900 Semiconductor Drive, Santa Clara, CA 95051). As shown in the functional block and pin connection diagrams, Fig. 1, the family includes four members—types LM2907, LM2907-8, LM2917, and LM2917-8. Described as "tachometer-speed switches," all four devices use the same basic monolithic chip, and each comprises a frequency-to-voltage converter and op amp/comparator. Supplied in 14-pin DIP's, the LM2917 differs from the LM2907 in that an on-chip zener regulator circuit is connected in the former to provide extra input protection. The "8" suffix versions are assembled in 8-pin DIP's and differ from the standard configurations in offering a ground-referenced input together with an internal connection between the frequency-to-voltage converter (tachometer) output and the op amp noninverting input. All four IC's can sink or source output currents of up to 50 mA, offer a typical linearity of ±0.3%, can dissipate up to 500 mW, and are designed for operation on dc sources of up to a maximum of 28 volts.

Despite their special-purpose designation, the tachometer-speed switches are exceptionally versatile devices and may be used in a variety of exciting and valuable projects. Depending on the peripheral circuitry and types of input and/or output devices used, these IC's can serve effectively in speed alarms, over/under speed monitors and controls, frequency-to-voltage converters, speedometers, breaker-point dwell meters, speed governors, tachometers, cruise controls, touch- or sound-activated switches, automatic door lock, clutch and horn controls, capacitance meters, delay switches, and anti-skid sensor/controls. Operating on 6-to-28-volt dc supplies, the devices can be driven by voltage or current sources or by special sensors, such as magnetic pickups, and can be used to drive LED's, power transistors, relays, SCR's, meters, and similar units requiring currents of up to 50 mA.

Although the tachometer-speed switch internal circuitry is relatively complex, its basic principle of operation is comparatively simple and straightforward. An external pulsating dc or ac signal, derived from a sensor or other source, is applied to a differential amplifier driving a positive feedback flip-flop. The flip-flop, in turn, controls a charge pump which charges or discharges an external capacitor between two voltage levels. The capacitor's average pump current is directly proportional

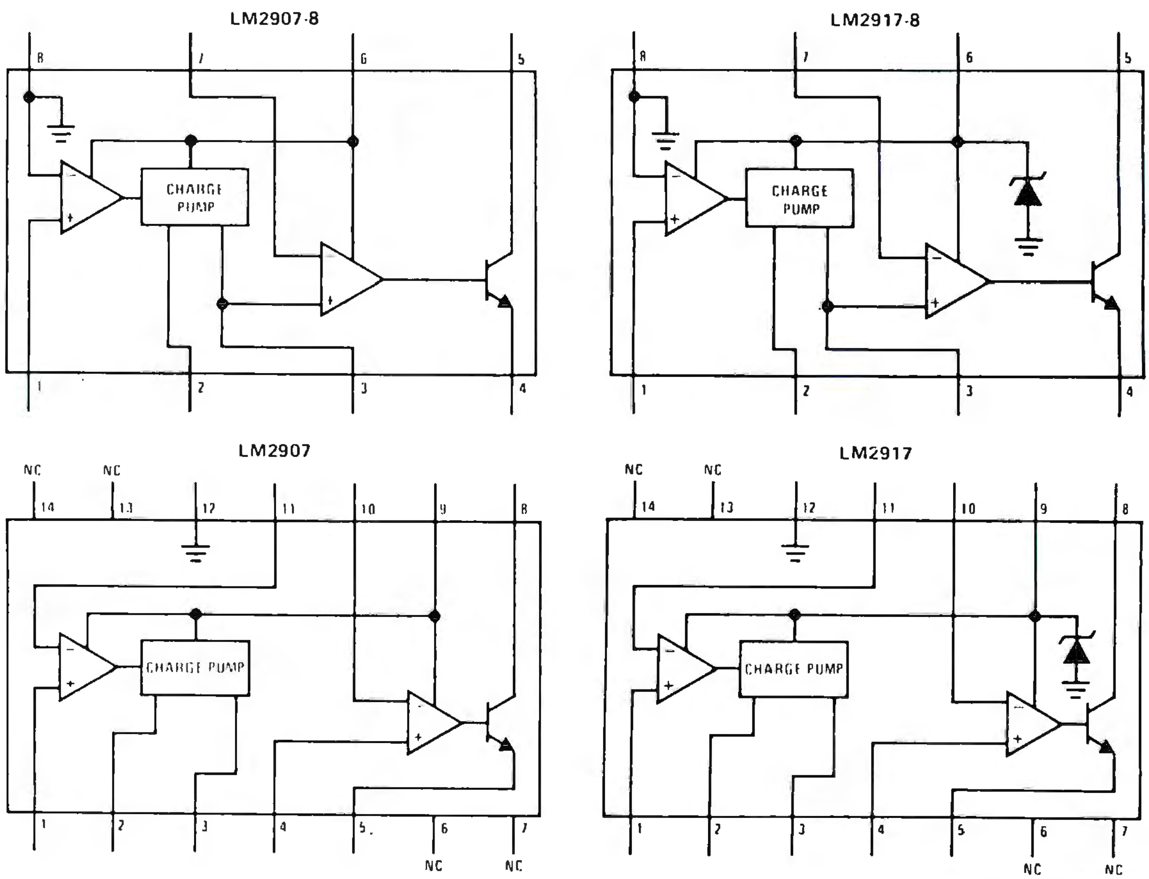


Fig. 1. Block and pin connection diagrams.

to the supply voltage, the capacitor's value, and the charging rate. Since the capacitor's value is fixed and the supply voltage constant, the pump current is *directly proportional to the input frequency.* Parallel drivers furnish a current identical to the pump current to an external load resistor, bypassed by a second capacitor to filter the ac ripple components. As a result, the average dc voltage across the external load resistor is also directly proportional to the input frequency. This portion of the IC—the input differential amplifier, flip-flop, and charge pump—constitute a basic frequency-to-voltage converter, or tachometer.

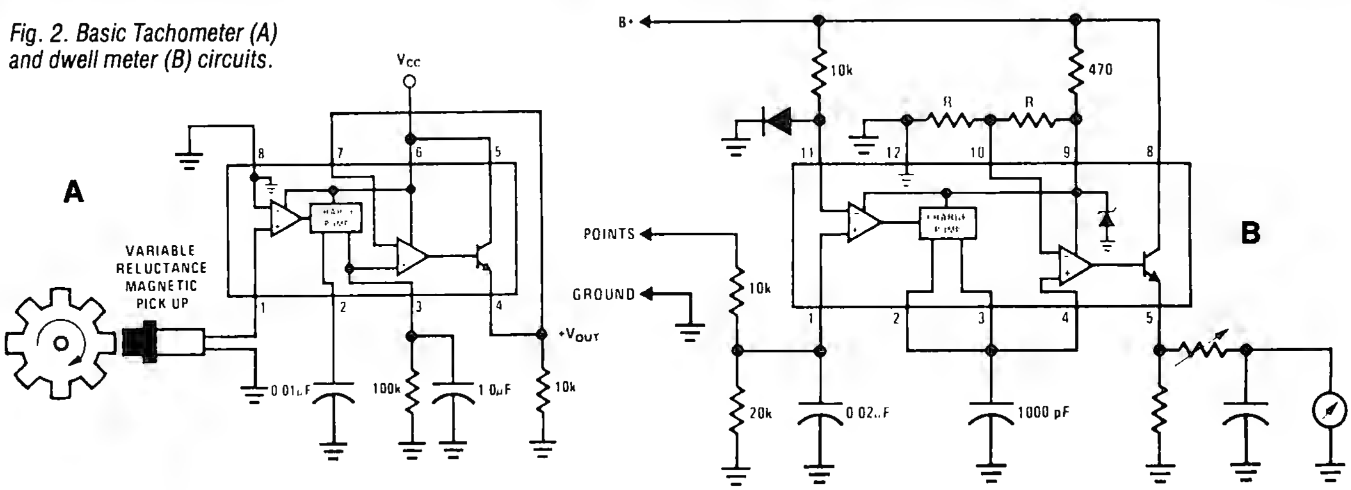
The tachometer section's output is coupled to an operational amplifier driving a medium-power-output transistor. Depending on the external connections, the op amp may be operated either as a conventional amplifier or as a voltage comparator. If the op amp is used as a voltage comparator, its output remains essentially at zero until the input frequency (hence the tachometer section's output voltage) reaches a predetermined value established by a fixed bias applied to its inverting input terminal. Driven by the op amp, the output transistor, an npn type, has uncommitted emitter and collector terminals, permitting it to serve either as a sink or source to an external load device such as a meter, LED, etc.

Typical application circuits for the tachometer-speed switch IC's are illustrated in Figs. 2, 3, and 4. Abstracted from the 14-page data brochure for the LM2907/LM2917 family published by National Semiconductor, these circuits are intended as general guides rather than as detailed construction plans and are suitable for use by more advanced experimenters and hobbyists as well as technicians and engineers. In some cases, not all component values are specified, for these must be determined by the individual designer to meet his specific performance requirements or to match external load devices, such as meters. On the other hand, as long as good wiring practice is observed, neither layout nor lead dress should be overly critical, permitting the individual designer/builder to use his own choice of assembly techniques, including perf board, pc board, or chassis construction and point-to-point wiring. Generally, all resistors are half-watt units, all capacitors either low-voltage ceramic or plastic film types, and all external diodes general-purpose devices.

Featuring the LM2907-8, a minimum component tachometer circuit is given in Fig. 2A. Here, a variable reluctance magnetic pick-up driven by a toothed wheel serves as the input sensor. The external charge pump capacitor is a 0.01-μF unit, while a 100,000-ohm resistor bypassed by a 1.0-μF capacitor serves as the tachometer section output load. The final output load is a 10,000-ohm resistor. In operation, the dc voltage developed across the output resistor is directly proportional to the input frequency and hence to the wheel rpm. If a suitable high-impedance voltmeter is connected across the output load, it can be calibrated directly in terms of rpm.

A few of the many possible automotive applications for the tachometer-speed switch IC are illustrated in Figs. 2B, 3A and 3B. A breaker point dwell meter circuit using the LM2917 is shown in Fig. 2B, while engine rpm meter circuits using the same device are given in Figs. 3A and 3B. The latter two circuits clearly illustrate the different ways in which the power output transistor may be used to drive an external load. The first, Fig. 3A, uses an emitter resistor as the output load to drive a dc voltmeter. With the component values given, an output of 6 volts dc is developed across the 10,000-ohm emitter resistor with an input frequency of 400 Hz, representing an 8-cylinder engine speed of 6000 rpm. The second design, Fig. 3B, employs a milliammeter as the output transistor's collector

Fig. 2. Basic Tachometer (A) and dwell meter (B) circuits.



load and thus represents a current-driven approach. In operation, an output current of 10 mA is developed with an input frequency of 300 Hz, representing a 6-cylinder engine speed of 6000 rpm.

Four of the many other potential applications for the tachometer-speed switch are illustrated in Fig. 4, including a zener regulated frequency-to-voltage converter featuring the LM2917-8, Fig. 4A, a direct-reading capacitance meter, Fig. 4B, a finger touch (or contact) switch, Fig. 4C, and an overspeed alarm indicator, Fig. 4D. The last three circuits all employ the LM2907-8. Using the 60-Hz ac power line as its input test signal source, the capacitance meter, Fig. 4B, develops a dc output of 1 to 10 volts across its emitter load resistor with C_x values of 0.01-to-0.1-μF and the calibration resistor, *R*, set at 111,000 ohms. A suitable high-impedance voltmeter connected across the emitter load may be calibrated directly in terms of capacitance. The touch switch circuit, Fig. 4C, uses the LM2907-8 to drive a standard J-K flip-flop. In operation, the flip-flop's Q output terminal goes "hi" and "lo" alternately each time the contact plate is touched. Depending on the intended application, the flip-flop's output may be used to operate a relay, indicator lamp, counter, or other circuitry. Finally, the overspeed indicator circuit, Fig. 4D, flashes a LED when its input frequency equals or exceeds a predetermined value. Thereafter, the flashing rate rises as the input frequency increases beyond the initial trip point. With the component values given, flashing begins with an input frequency of 100 Hz or more. This range may be changed, however, by changing the value of the charge pump capacitor (indicated as 0.033 microfarads).

Reader's Circuits. Our correspondent in Florida, Ted Reiter (1442 Brook Drive, Titusville, FL 32780), is back again this month with more of his interesting circuits. Feeling that many of his fellow experimenters might require time sequencing circuits for their projects, Ted suggests the designs given in Fig. 5 as simple solutions for problems which might otherwise require relatively complex circuits or expensive components. An "active low" sequencer circuit is shown in Fig. 5A, an "active high" in Fig. 5B. Both require only a 555 timer, a SN7495N 4-bit shift register, and a minimum of additional components. Both are designed to operate on a standard 5-volt dc power supply. Finally, both are not overly critical as far as parts placement and wiring dress are concerned and, therefore, may be duplicated with any preferred construction technique from solderless breadboarding to pc board assembly.

Referring to the active low sequencer circuit, Fig. 5A, the 555 is wired as a pulse generator or "clock," with its pulse rate (frequency) adjustable by means of a 1-megohm potentiometer. In operation, the shift register outputs at pins 13 (A), 12 (B), 11 (C), and 10 (D) are high initially. When normally closed switch *S1* connected to mode input pin 6 is opened momentarily, the next negative-going clock edge switches pin 13 (A) to low. Each following negative edge then moves the low one position to the left from A to D. In logic symbols, using "1" for high and "0" for low, the sequence is as follows:

	D-C-B-A
Originally:	1-1-1-1
Initiate:	1-1-1-0
	1-1-0-1
	1-0-1-1
	0-1-1-1
Recycle:	1-1-1-0
	1-1-0-1

and so on, recycling as long as power is supplied and the clock is on. Using the same clock circuit, the active high sequencer operates in similar fashion, except that the shift register outputs are low (logic 0) initially and a high (logic 1) is sequenced from A to D after the *initiate* button is pressed. The clock frequency, of course, establishes the cycling rate.

Although the sequencer outputs are shown in logical order, they can be used to operate external circuitry or devices in any order desired, provided the user remembers that the "A" output is active (high or low) before "B," "B" is active next before "C," and so on.

Sequencer applications are limited only by the imagination and skill of the circuit designer and by the types of peripheral circuitry or external devices controlled. Ted suggests, for example, that a sequencer could be used to cycle several lights on and off for unusual displays, for sequencing several slide projectors for special color-slide presentations, for cycling a CB transceiver through several channels, or for sequencing several audio tones in an electronic "doorbell," as indicated in Fig. 6. Other possible applications include the familiar turn indicator for autos (or bikes), for "bouncing" sound around a room by switching loudspeakers on and off sequentially, or for sequencing test operations in a laboratory. Generally, some type of interface device, such as a relay, power transistor, or SCR will be required between the sequencer output and the controlled device (lamp, loudspeaker, alarm bell, motor, or

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CREI programs are approved for training of veterans and servicemen under the G.I. Bill.

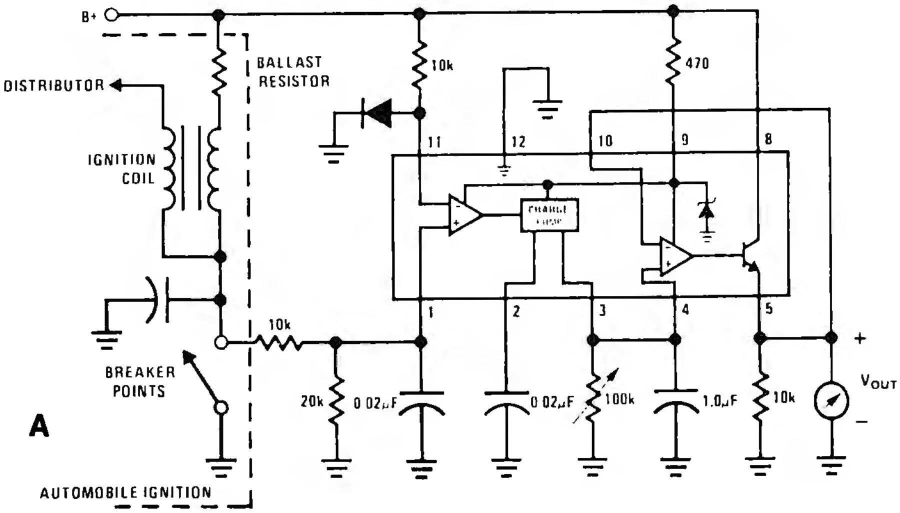


Fig. 3. Automotive tachometer circuits: (A) voltage-driven for 8-cylinder cars; (B) current-driven for 6-cylinder cars.

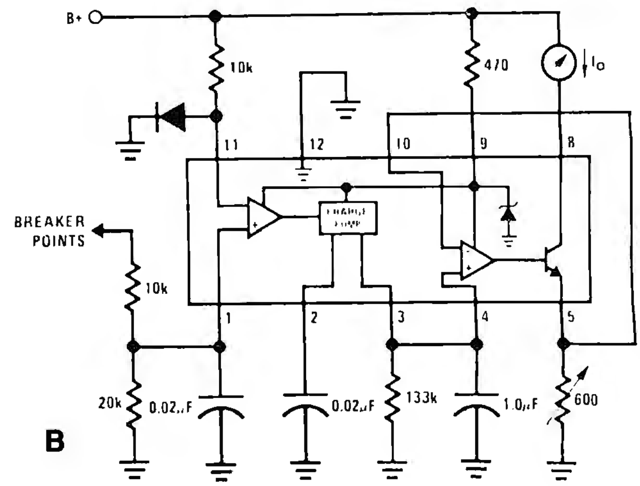
other unit) if moderate to high power levels are involved, with the interface and controlled devices requiring a separate power source.

Device/Product News. If you're working with r-f circuits, either professionally or as a ham, you may want to investigate a pair of solid-state vhf and hf amplifier modules recently introduced by the *Amperex Electronic Corporation* (Hicksville, NY 11802). Containing internal matching networks for broadband applications, each module will deliver better than 18 watts with a drive power of less than 150 mW when operated on a dc supply of 12.5 volts. The BGY32 is designed for operation at 68 to 88 MHz, the BGY36 from 148 to 174 MHz. Their input and output impedances are matched to 50 ohms with no instability at VSWR's of up to 3:1 at all phase angles, but neither will be damaged with VSWR's of up to 50:1 through all phase angles at heat sink temperatures as high as 70°C.

In addition to the new r-f amplifier modules, Amperex has announced a new full-wave silicon bridge rectifier designed specifically for use in semiconductor equipment. Designated type BY225-200, the rectifier has a maximum rms input rating of 80 volts and can supply an average output current of 4.2 A. Suitable for use at frequencies up to 400 Hz, the rectifier consists of four double-diffused diode crystals on a copper comb encapsulated in plastic. Capable of delivering up to 3 A without a heat sink, the device can be used in power supplies for musical instruments, audio amplifiers, boat equipment, burglar and fire alarms, battery chargers, microprocessors, and other equipment requiring up to 90 W output.

The *Fairchild Camera and Instrument Corp.* (Analog Products Division, 464 Ellis St., Mountain View, CA 94042) is producing a hybrid voltage regulator capable of providing 5 A of regulated power at 5 volts with built-in short circuit and safe area protection. The voltage regulator, type 78H05KC, limits the maximum junction temperature of the power output transistor to provide full automatic thermal overload protection. If the safe operating area is ever exceeded, the device simply shuts down rather than failing or damaging other system components. The device is supplied in a standard TO-3 package.

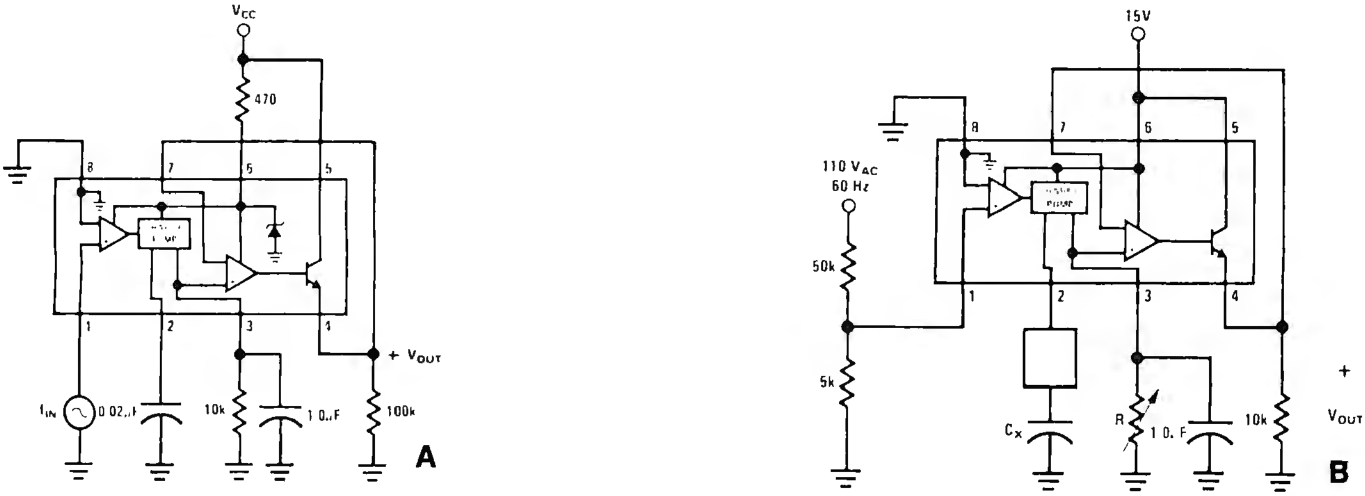
Teledyne Semiconductor (1300 Terra Bella Ave., Mountain View, CA 94042) has added two new up-down (reversible) counters to its growing family of high-noise immunity logic devices. The HiNIL 373 (decade) and 374 (hexadecimal) counters feature master-slave flip-flops with active outputs triggered by a low-to-high level transition of either of two clock in-

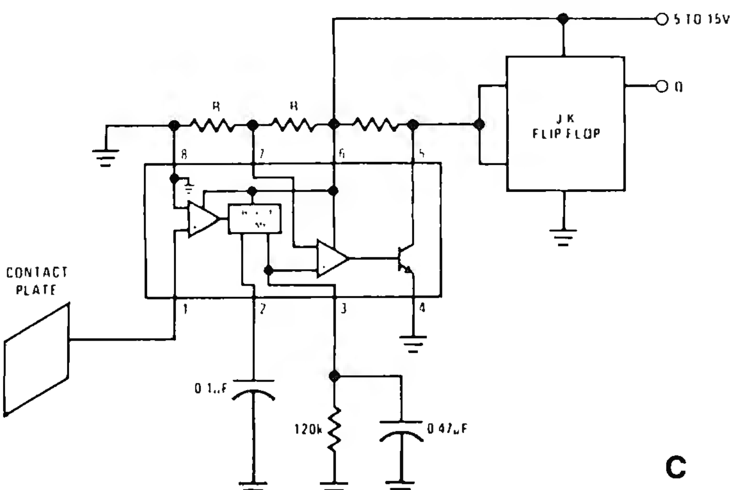


puts while the other is high. Pulsing one clock input causes the device to count up; pulsing the other causes it to count down. Other features include the high noise immunity—3.5 V minimum, carry and borrow outputs for N-bit cascading, clear input independent of count and load, individual preset for each flip-flop, and synchronous operation. Furnished in standard 16-pin plastic and ceramic DIP's, the HiNIL 373 and 374 counters are suitable for critical control, medical instrumentation and marine electronic applications.

Motorola Semiconductor Products, Inc. (P. O. Box 20294, Phoenix, AZ 85036) has added four new npn power Darlingtons to its expanding line of "Switchmode" products. Designated types MJ10004, MJ10005, MJ10006 and MJ10007, the units are designed specifically for fast switching applications where high voltage, high current and high gain are required. Maximum currents are 40 A for the MJ10006 and MJ10007, both of which offer a minimum h_{FE} of 40 (@ I_C of 2.5 A), and 50 A for the MF10004 and MJ10005, which offer a minimum h_{FE} of 50 (@ I_C of 5 A). The devices feature typical fall and storage times of 100 ns and 850 ns, respectively, for the MJ10004/5 and 90 ns and 780 ns, respectively, for the MJ10006/7, when switching an inductive load of 180 µH with the devices clamped at their rated V_{CEX}(sus) and at case temperatures of 100°C. The minimum V_{CEX}(sus) at a case temperature of 100°C is 400 volts for the MJ10004/6 and 450 volts for the MJ10005/7.

Finally, *RCA*'s Solid State Division (Box 3200, Somerville, NJ 08876) has added three new sensitive-gate SCR series, S106, S107, and S108, to its line of silicon-controlled-rectifiers. The new SCR's have an rms on-state current rating of 4





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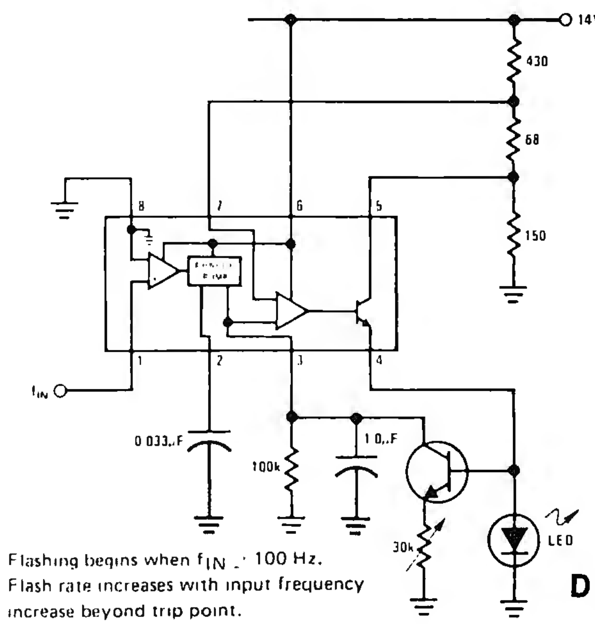
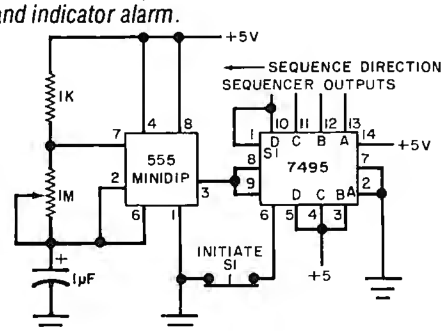
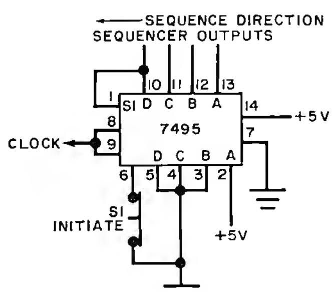


Fig. 4. Additional tachometer-speed switch applications circuits: (A) frequency-to-voltage converter; (B) capacitance meter; (C) finger-touch circuit; (D) overspeed monitor and indicator alarm.

A. Each series includes nine types with voltage ratings of 15, 30, 50, 100, 200, 300, 400, 500, and 600 V, and all utilize the standard JEDEC TO-202AB package. The new series of devices is intended for lighting, power-switching, motor-speed controls and for gate-current amplification for driving larger SCR's, while the gate-current characteristics of the S108 series makes it ideal for low-level logic circuit applications. ◇



(A)



(B)

Fig. 5. Reader's sequencer circuits: (A) active low; (B) active high.

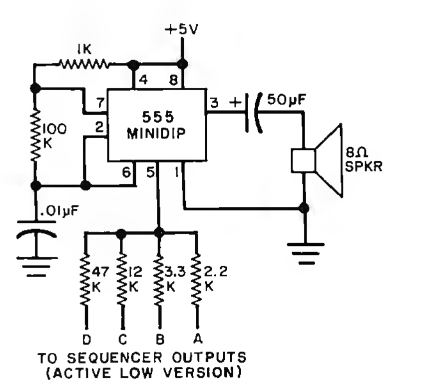


Fig. 6. Possible application of sequencer to an electronic "doorbell."

Experimenter's Corner

By Forrest M. Mims

FLIP-FLOPS AND DECADE COUNTERS—PART 2

WE HAVE previously seen (February 1976) how a clocked flip-flop can be used as a binary counter. We built a two-bit binary counter from both halves of a 7473 dual JK flip-flop. And we assembled a limited range (0-9) four-bit counter from a 7490 decade counter, a medium-scale integrated circuit (MSI) which incorporates four flip-flops on a single chip.

Now, let's see how to add an additional chip or two to the 7490 to make it a more versatile counter. We'll also examine several ways to convert the 7490 into a divide-by-n counter.

Binary-Coded Decimal. Four clocked flip-flops have the potential of counting from 0000 to 1111 in binary (or 0 to 15 in decimal). The 7490, however, is internally connected to automatically reset to 0000 when the count exceeds 1001 (9). This feature gives the decade counter its name and makes it ideal for converting binary information into a decimal format.

A pure binary counter is very easy to build, but our decimal-trained minds would have considerable difficulty relating to it. It's not too hard to learn the binary equivalents of 0-9, but how about the binary equivalent of a number like 215? The binary number in this case requires 8 bits and is a very cumbersome 11010111.

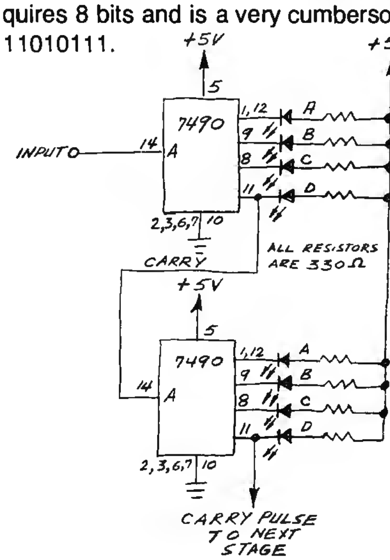


Fig. 1. How to connect two or more 7490 counters in series.

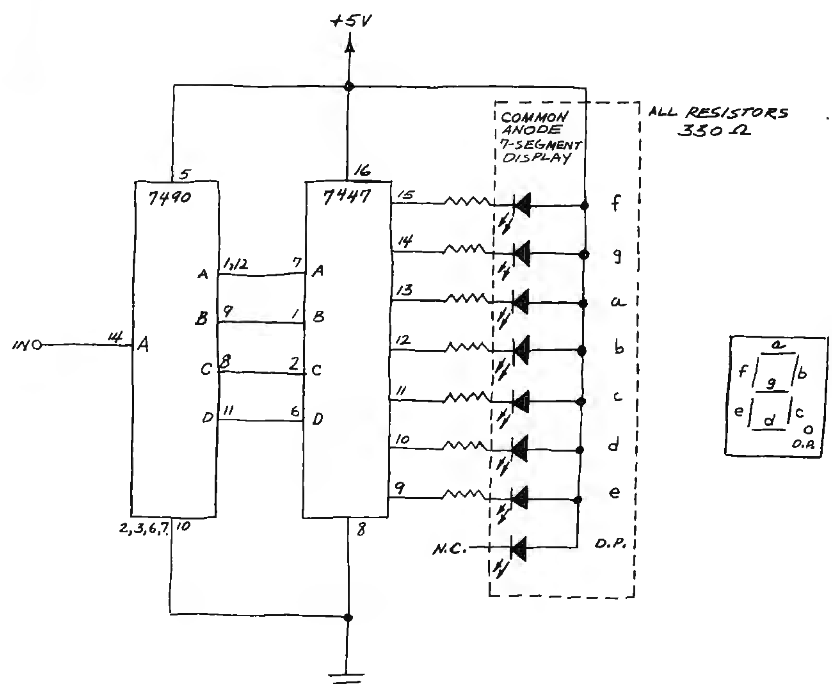


Fig. 2. Converting 4-bit BCD output of 7490 to decimal.

Fortunately, there's an easier way to work with binary numbers. It's called *binary-coded decimal* or BCD for short. The four-bit outputs of individual 7490's can form a binary-coded decimal number. The elegance of BCD is its simplicity. Since each counter stage represents one decimal digit position, only the binary equivalents for the digits 0-9 need be learned to interpret the pattern of glowing LED's connected to each 7490. For example, assuming a dark LED is 0 and a glowing LED is 1, 215 would be represented in BCD as 0010 0001 0101, instead of 11010111 in pure binary.

It's not even necessary to memorize *any* binary numbers to read a BCD LED display since you can use a simple trick to convert any binary number to its decimal equivalent. Here's how it works: The positions of bits in a binary number represent ascending powers of two (just as the positions of digits in a decimal number represent ascending powers of ten). For example, the decimal values for each position in a four-bit binary number

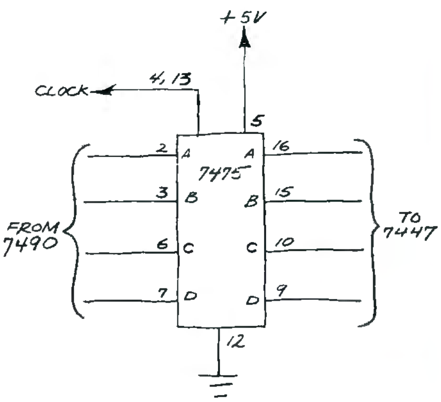


Fig. 3. How to connect a latch between a 7490 counter and a 7447 decoder.

are: $2^3-2^2-2^1-2^0$ or simply 8−4−2−1. This means that by ignoring the 0 bits and adding the powers of two at the positions with a 1 bit you can quickly arrive at the decimal equivalent for a binary number. For example, 1001 is 9 (8 + 0 + 0 + 1), and 0111 is 7 (0 + 4 + 2 + 1).

The 7490 Decade Counter. A look at the pin diagram of the 7490 shows its four output pins are given the conventional BCD designation DCBA. The pin diagram doesn't reveal a carry pin so it would seem the 7490 cannot be used for multiple digit applications. Fortunately, however, it's possible to use the D output as a carry pin. All that's required is to connect pin 11 of the 7490 in the first counter stage to the A input of the 7490 in the second stage (pin 14) as shown in Fig. 1. This neat solution to the absence of a carry pin works since the 7490 in the second stage triggers when the count from the first 7490 recycles from 1001 (9) to 0000. Also, it can be applied to a succession of counter stages.

Several counter stages can be used to make an eight–, twelve–, sixteen–, or more bit BCD counter. Each counter's four-bit row of LED's would represent a single BCD digit. But though this arrangement is very economical, it's not as convenient as a digital output.

The 7447 7-Segment Decoder. One way to convert the four-bit BCD output of a 7490 into a decimal format is to use a diode matrix read-only memory (ROM) programmed to light one of ten LED's labeled 0-9. A more convenient approach is to use a ROM or array of gates connected to light the appropriate segments of a segmented 0-9 digital display. There are several chips which will do this for you.

Figure 2 shows how to connect the 7447 BCD to 7-segment decoder/driver between a 7490 decade counter and a common-anode segmented LED display. The 7447 includes several useful features. Grounding the lamp test input (pin 3) will light all seven segments of the display. Grounding the ripple blanking input (RBI; pin 5) will blank the display if a 0 is being displayed. And grounding the ripple blanking output (RBO; pin 4) will blank the readout no matter what digit is being displayed.

The 7475 Four-Bit Latch. The multi-digit counter circuit in Fig. 1 is adequate for counting a series of events or the passing of time up to the maximum digit capability. Many counting applications, however, require the measurement of frequency (the count rate per unit time). For example, a frequency counter counts the number of incoming pulses during a preset time interval (say, 1 second), then recycles and begins counting again. In cases like this the 7490 is always busy counting and all seven display segments will blur into a meaningless "8" if the count exceeds several pulses per second.

The simplest way around this problem is to connect a temporary memory between the 7490 counter and the 7447 decoder. The ubiquitous flip-flop comes to our rescue again, this time in the form of a four-bit data register called the 7475 quad-latch. This handy chip contains four flip-flops and interfaces between the counter and display circuitry as shown in Fig. 3

The 7475 accepts BCD data and passes it to the display when its clock inputs (pins 4 and 13) are high (ungrounded). When the clock inputs are grounded, the 7475 stores whatever data was last present at its inputs and the display is activated accordingly.

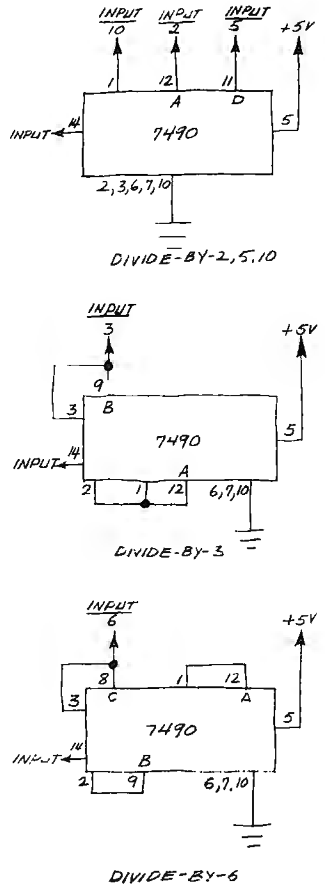


Fig. 4. How to use the 7490 as a divide-by-n counter.

7490 Divide-by-n Circuits. So far, we've covered the most important decade counter applications for the 7490. By now, in fact, you should be able to trace your way through much of the circuit diagram of a professional frequency counter! The 7490 has a number of divider applications also, and Fig. 4 shows how to connect it to achieve division.

The divide-by-2, 5, and 10 circuits are made possible by the internal arrangement of the 7490 as a single flip-flop and three interconnected flip-flops. The divide-by-3 and -6 circuits are made possible by connections between the BCD outputs and the appropriate reset inputs of the 7490 which automatically reset the counter to 0000 when the desired count is reached. The result is one pulse out for every n pulses in. ◇

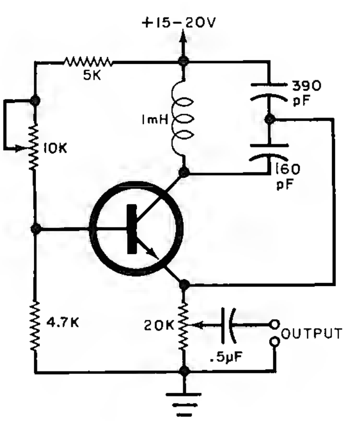
Hobby Scene Q&A

By John McVeigh

RECEIVING SSB

***Q.** I have a Heathkit SW-717 shortwave receiver that works very well, but I can't copy most ham voice stations. They all sound garbled. I was told that this is normal as they are using single sideband transmitters. Is there a circuit I can build that will enable me to understand what they're saying?—Harry Muller, Elkins Park, PA.*

A. What you need is a beat frequency oscillator or bfo to re-insert the suppressed carrier of the SSB signals. The circuit shown will work with your receiver. Its output signal can be introduced at either the 455-kHz i-f strip or at the diode detector. In some cases, merely con-



necting a length of hookup wire to the output and positioning it close to the i-f circuitry will provide enough coupling. Otherwise, you can connect the other end of the wire to the anode of the detector. Adjust the 10,000-ohm potentiometer for maximum output and the 20,000-ohm potentiometer for greatest intelligibility. By the way, you will also be able to use this bfo for hearing Morse code signals.

FAST AND SLOW SCAN TV

***Q.** I recently read in an article covering the Viking mission that TV transmissions are being sent on the 20-meter band. As I understand it, the picture is converted into a 3000-Hz tone and sent by "radio." Is it possible to convert these tones back into video and feed it to my TV receiver? Incidently, the call of the station sending the pictures is N6V. —Craig Keithley, Northridge, CA.*

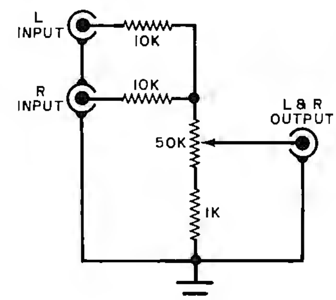
A. The article was referring to slow-scan television, as opposed to the conventional fast-scan system broadcasters use. The great advantage of slow-scan is that it requires no more spectrum space ("bandwidth") to send a picture than is needed for a voice signal—about 3000 Hz. However, the bandwidth of a communications channel has a direct influence on the maximum rate at which data can be sent over the channel. Because slow scan is a narrow bandwidth system, it takes much longer to send a picture over it than a fast scan link. The actual figures are about 8 seconds for a slow-scan picture as compared with 1/30th of a second for fast scan—but fast scan requires about 4 MHz (!) of spectrum space. If I recall correctly, the Viking project uses a slow-scan technique for sending back pictures, requiring about 30 minutes for the entire image to be transmitted.

The N6V station is a special events Amateur Radio station operating from the Jet Propulsion Laboratory in Pasadena. Although I did work it on 20-meter SSB (voice), I was not monitoring the station when they were sending slow-scan images of the "marscapes" received from Viking. Slow-scan pictures can not be applied directly to a TV set. They must be processed by a "scan converter"—a complex circuit that changes them to fast-scan signals. Scan converters are very expensive, and slow-scan images do not have the high resolution that fast-scan ones have. However, such books as The Radio Amateur's Handbook and Specialized Communications Techniques for the Radio Amateur (both published by the ARRL, 225 Main Street, Newington, CT 06111) contain plans for SSTV monitors and adapters for use with oscilloscopes.

PASSIVE MIXER

***Q.** I would like to play a stereo tape deck through a monaural amplifier. Is there a network that will combine both channels?—John Riley, Burbank, CA.*

A. The circuit shown will combine the stereo input and provide a balanced monaural output. This passive mixer includes an attenuation control which determines the amount of signal that will be passed to the power amplifier. You



can set the playback level controls on the deck fairly high and cut back to the desired level by adjusting the 50,000-ohm potentiometer.

RANGE OF CB HANDHELDS

***Q.** I recently purchased a pair of CB handhelds which supposedly have an r-f power output of four watts. So far, I haven't been able to communicate with them over a range greater than three miles or so. Is there any way I can increase their range with boosters, or whatever?—Bruce Leavenworth, New Preston, CT.*

A. First of all, "boosters" such as linear amplifiers are *strictly* prohibited. Penalties for use are severe, and the FCC is interpreting "possession" as implying "use." Therefore, I strongly discourage your thoughts along those lines. But I don't think that a 3-mile maximum is unreasonable. That figure is typical for many mobile installations, and even though mobile antennas are not very efficient, I think they perform better than the telescoping whips of handhelds. If your transceivers have external antenna jacks, try using a more efficient base or marine-type antenna. That's the only recommendation for increasing range that I can make.

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

Product Test Reports

OK MODEL WSU-30 WIRE-WRAP TOOL

Manual Wire-Wrapping tool for solderless breadboarding.

Experimenters and hobbyists, and even many engineers, generally reach for soldering iron and hookup wire when it comes to assembling a circuit. The more ambitious people lay out a printed circuit board, make the board, and then wire it in the conventional manner—still having to use a soldering iron. Recently, Wire Wrap has become a popular wiring medium, especially where hundreds and thousands of connections must be made in very complex projects.

Though Wire Wrapping is not new to the electronics industry, it has been relatively rare among hobbyists. Now, a battery of new and inexpensive tools is coming on the market. One such tool is the Model WSU-30 at $5.95 from OK Machine & Tool Corp.

The Model WSU-30 Wire Wrap tool features all-metal construction. Measuring 4½" (11.4-cm) long, it weighs a mere 0.5 ounce (15.5 g). The tool serves three functions. First, it has a built-in stripper for removal of the special Kynar insulation used on Wire Wrap wire. Second, it is a manual Wire Wrapper. Finally, it is a wire unwrapper.

General Details. The use of a Wire Wrap tool, such as the Model WSU-30, carries with it several advantages that make it attractive to the engineer, experimenter, and hobbyist. Since it is a solderless wiring medium, it eliminates the need for a soldering iron and, thus, the possibility of heat damage to components. While it is essentially a point-to-point wiring medium, Wire Wrapping allows you to make connections with a rapidity that cannot be matched by crimp-and-solder joints. Furthermore, errors in wiring can be corrected and circuit modifications can be made in seconds. In sum, Wire Wrapping is much faster than traditional methods of wiring circuits, including pc board construction, which is not only messy to make but also extremely difficult to modify.

The use of the Model WSU-30 Wire Wrap tool is very simple. You start by inserting the unprepared end of the wire in a V-shaped slot in the body of the tool, press down slightly on the wire to score the insulation, and then draw out the wire. The insulation parts neatly, leaving a bare-wire end. Next, you feed the bare wire into a small hole in the wrap end of the tool, place the tool over a Wire-Wrap pin on either a socket or component pin, and rotate the tool clockwise. As the tool is rotated, the bare end of the wire wraps tightly around the pin. The recommended number of turns for an optimum joint is seven turns.

Wire-Wrapped joints have high electrical and mechanical integrity because the relatively sharp corners on the wrap pins "bite" into the wire as it is wound around them under tension. Wire Wrap connections have been known to maintain their mechanical and electrical integrity for as many as 40 years. And tests reveal that the typical Wire Wrap joint has a contact resistance of less than 1 milliohm.

To unwrap a connection, you simply invert the tool, slip it over the wrap pin, and rotate the tool counterclockwise. The wire comes away from the post neatly and easily.

User Comment. We tested the Model WSU-30 Wire Wrap tool by assembling several circuits, one of which was a complex computer board. After making a few trial wraps to become familiar with the operation of the tool, the wiring went very quickly and easily. We found that, with a little practice we were making connections, including stripping away of insulation, at a rate of about one every 10 seconds.

We also had a practical opportunity to test the unwrapping feature of the tool. After our computer board was completely wired, we had to make a modification that involved about three dozen conductors. Again, the job went quickly and rapidly.

Comparing this new low-cost tool with an expensive motorized Wire Wrap tool, we determined that both produced the same high-quality, high-reliability connections, although we must admit that the mechanized tool had the edge when it came to speed. But the low cost of the Model WSU-30 had a big edge in the price category.

You can buy the Model WSU-30 Wire Wrap tool only, but it is a good idea to pick it up in the prepackaged kit form, which also contains a 50′ (15.2-m) spool and stripped 1" to 6" (2.54- to 15.2-cm) lengths of Kynar insulated wire for $11.95. Spools containing 50′ of wire are also available separately for $1.95 per spool. The standard wire used with the Model WSU-30 Wire Wrap tool is AWG 30 silver-plated, Kynar insulated interconnection wire.

CIRCLE NO. 82 ON FREE INFORMATION CARD

Strip.

Wrap.

BALLANTINE MODEL 1010A OSCILLOSCOPE

Moderately priced, dual-trace, trigger-sweep, 10-MHz-bandwidth scope.

To properly and efficiently perform design, troubleshooting, and maintenance of modern electronic circuits, you need a full-featured oscilloscope. It should have a relatively wide bandwidth, dc coupling throughout, triggered sweep, and a frequency and interval counter that is not sensitive to waveform shape. More than one input channel will make such a scope all the more versatile. The Ballantine Model 1010A oscilloscope fills the bill for most modern electronics work.

The Model 1010A scope features a 5" (12.7-cm) flat-screen CRT; two fully independent input channels that operate on either the alternate or chop mode to provide two traces from the single beam; dc-to-10-MHz bandwidth (at the 3-dB-down points); and triggered sweep.

The scope measures 16 5/8"D × 11 3/8"W × 7"H (42.2 × 29 × 17.8 cm) and weighs 15 lb (7 kg). $595.00. A number of options are available, including the No. 10600 probe kit for $35, No. 10850B r-f detector probe to allow the scope to be used out to 700 Mhz for $85, a vinyl carrying case, and front-panel cover.

General Description. The two identical vertical input channels have a deflection factor of from 20 mV to 20 volts/cm. The deflection factor desired is selectable by a front-panel switch that has 12 calibrated positions. The direct-coupled bandwidth is stated to be at least dc to 10 MHz at −3 dB, while on ac coupling, the lower-frequency 3-dB-down point is at approximately 5 Hz. The input impedance, identical for both channels, is 1 megohm paralleled by 28 pF. Both inputs are protected up to 400 volts dc or peak ac.

The triggered-sweep section has a range of from 1 μs to 0.5 second/cm in 18 switch-selectable ranges. The accuracy here is stated to be within 5%. A ×10 magnifier, available at the flip of a front-panel switch, makes the fastest sweep 100 ns/cm. The sweep circuit also features a vernier control that is continuously variable between time-base steps. It extends the sweep to 1.25 seconds/cm. The sweep can be triggered either automatically or manually from either channel's signal or from an external source. The three trigger coupling modes provided are AC, ACF (ac fast with low-frequency rejection), and TVF (TV frame rate).

Each of the two vertical channels can be selected for single-trace display only. Setting the scope to the dual-channel mode allows both traces to appear on the CRT screen simultaneously, with the alternate or chop mode automatically selected by the choice of sweep speeds.

In addition to intensity (Z-axis) external modulation, the scope also features a 1-volt ±2% square-wave output, available at a jack on the front panel, that can be fed back into the scope for calibration purposes. This output signal's frequency is the same as the line-power frequency. There is also a sweep-synced ramp output, available from a separate front-panel jack, that goes from 0 to 10 volts.

The input to the power transformer can be selected to allow operation from 95 to 260 volts ac, with line frequencies ranging from 45 to 400 Hz.

User Report. Using an oscilloscope like the Model 1010A is pure pleasure. Aside from the fact that it is a really versatile instrument, this scope is light enough in weight to carry from one job to another without tearing your arm from its socket. It is also quite rugged, capable of withstanding mechanical shocks that might ordinarily knock other scopes out of calibration. A couple of weeks of lugging it around in a field-service van confirmed this point admirably. Needless to say, the Model 1010A is as good as a field-service performer as it is on a fixed rack (it is available in rack mount) and bench.

Ballantine has not sacrificed creature comforts in keeping the price down. For example, all front-panel control knobs are large and have flutes for easy grip and manipulation. They operate smoothly and positively. And the knobs have full-length white index marks that, in addition to the large and easy-to-see panel legends, make settings easier to see and interpret than is usually the case. The flat-faced CRT has a P31 blue phosphor that is easy on the eyes, and its 8 × 10-cm graticule is clean and bold.

Another nice feature is the carrying handle. It has a locking mechanism that can be set for carrying the instrument from one job to another or adjusted to serve as a tilt stand on a service bench. The heavy-duty aluminum handle has a plastic grip with molded finger ridges. This grip also serves as an anti-skid "foot" when the handle is used as a tilt stand. When the optional molded faceplate cover is in place and the handle is hinged up, the two lock together. On the test bench, we discovered that this scope could resolve nanosecond trigger waveforms that we presumed were beyond the limits of the instrument. Even at these extreme limits, the sync held rock steady, and the trace was quite "readable" at the very high writing speeds used. A hallmark of this scope is clearly its bright, sharp trace at high speeds. Performing calibration tests, we also determined that the scope operated well within its published specifications. After stints on a service bench and in the field, where we made no particular efforts to treat it with any special care, we again subjected the scope to calibration tests. There was no detectable difference in any area we tested.

Considering the versatility, performance, and portability of this general-purpose oscilloscope, we feel it is an especially fine value for the bench and for the field-service technician and serious experimenter/hobbyist. One can easily get less scope for the money than the Ballantine Model 1010A. Equivalent specifications don't tell the whole story.

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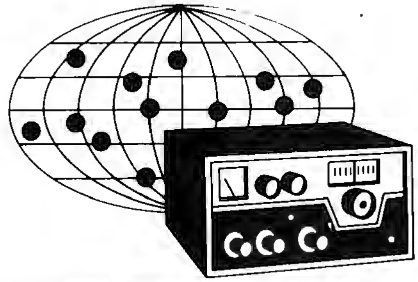


DX Listening

By Glenn Hauser

THE SOVIET PULSER

PULSES at the rate of ten per second have been disrupting shortwave communications since the middle of last year. These clicks follow no particular frequency schedule, but they often fall within shortwave broadcast bands. Having one channel at a time disrupted this way would not be so bad, but a single transmitter of this type may spread over a 300-kHz range, messing up an entire band at once. And some monitoring stations have reported three different pulse transmitters operating simultaneously.

Several press reports on this have been widely syndicated. They result from complaints the FCC has been receiving from amateur operators, point-to-point and maritime communications services using hf. It seems that the FCC has heard relatively little from shortwave listeners, who are less able to identify and combat this interference than "professional" users of the hf bands. In fact, reading the reports, one would never know that the pulsers cause havoc in international broadcasting.

FCC and equivalent administrations in other friendly countries have pinpointed the signals as coming from either "the Baltic area," or somewhere near Minsk in the Byelorussian SSR. As a result, numerous official protests have been filed with Soviet authorities.

In December, the USSR finally said it would try to reduce the disturbances in response to the complaints.

The purpose of the pulses has been a matter of wide speculation. Jim Vastenhoud of Radio Nederland likens them to ionospheric sounders for scientific research. Larry Magne of IBA observes that they seem to "ride the MUF," which means they operate at whatever frequency is the highest that will propagate at any given moment. Bob Thomann of the Swiss shortwave service thinks they carry intelligence, using "shotgun communication" so that, if one frequency is blocked, another will get through. But other observers find no evidence of intelligence in the transmissions.

David Mackes, a radar authority in Baltimore, is certain that we have been witnessing a new kind of long-distance radar which is called over-the-horizon backscatter.

Conventional radar uses more rapid pulses at super-high frequencies, which has the advantage of relatively high resolution, being able to track swiftly-moving objects. But the disadvantage is its limited range.

Mackes says a wideband pulse is transmitted, but is compressed in the receiver, making the pulse seem much greater in amplitude. He thinks linear FM is the modulation method; that is, the signal is most likely being chirped. Further studies of the pulses on a spectrum analyzer should give the answer.

Strong broadcast signals are capable of overriding the pulser, but it pops in between channels, making reception of weaker stations impossible. If you hear it on a single frequency, it's probably being relayed inadvertently, such as from BBC-Antigua or Radio Nederland-Bonaire.

Some authorities believe the 10-per second rate is far too slow to detect aircraft, even though it can reach beyond the horizon. This leaves shipping in the North Atlantic as the most likely target—certainly beyond the range of conventional radar based in the USSR. Other engineers think the Doppler effect is used, with performance good enough for tracking aircraft, according to Mackes. He also observed one pulse transmission centered on 6050 kHz, with 50-kHz bandwidth, followed by a CW station on the center frequency. We have noted the pulser at various times centered on 5.980, 7.635, 9.150, 9.600 and 11.715 MHz. Reception correlates well with that of Radio Moscow transmissions from the same geographical area.

Communications technicians in the Canadian north suspect the pulses had defense implications, as did Italian authorities last summer when the pulses first appeared, coinciding with NATO exercises.

More Change in the Air. Continuing our discussion of band reallocation, which began in the November 1976 DX Listening column, the present sharing of the 3- and 7-MHz bands between amateur radio and broadcasting has proven to be a terrible nuisance to broadcasters, hams, and listeners alike. There is no reason why this should continue beyond 1979. It is proposed that the hams give up the 3900–4000-kHz portion of 80 meters, while broadcasting gives up the 7100–7300-kHz portion of 40 meters. Of course, the amateur radio lobby has launched its own campaign for expanded and additional bands. There should be enough formerly IFPS spectrum for both broadcasting and amateur radio to have expanded, additional, and exclusive bands. An ARRL representative has been observing the IBSG meetings.

Mediumwave Band. The Mediumwave (or mf) band has already been reallocated outside the Americas, with an effective date in the fall of 1978. All European channels will move 1-kHz higher, which will result in a different selection of DX possibilities for American listeners. Even more radical is the adoption of Eurafrica's 9-kHz spacing, instead of 10, in Asia and the Pacific. Though American DX listeners have had to tune for these areas on the same channels as domestic stations, the shift will open up many "splits," allowing propagation and receiver selectivity to determine DX success, rather than domestic interference!

The IBSG has also considered changing the present 5-kHz spacing in the hf bands to 7.5 kHz. This might appear to be a loss, rather than a gain, but the argument is this: when combined with wider bands, the increased spacing would mean a net gain of usable channels. Every channel could be used effectively to the same area at the same time. Now, a channel 5 kHz away from a powerhouse on either side is best skipped, though some stations have to use such channels for lack of anything better. For example, strong stations on 11,720 and 11,730 would make 11,725 useless. If the strong ones were on 11,715 and 11,730 instead, the 11,722.5-kHz channel in the middle could also be used; and there would be no stations on 11,720 or 11,725.

Compatible single sideband would help make this work, replacing the present double sideband (AM). In CSSB, the carrier remains, though it may be slightly reduced. But there is only one sideband. This means a "narrower" signal, still conveying the essential audio that is now needlessly duplicated on the other sideband. The remaining carrier makes it compatible—that is, receivable—on ordinary tuners, unlike amateur SSB which suppresses the carrier.

CSSB adoption would also make *stereo* broadcasting possible on hf by reinstating the other sideband, but with right and left channel, rather than identical audio. This would be restricted to single-hop transmission paths as fading would ruin shortwave stereo. The technique for CSSB has been known for a long time. Stereo AM has already been tested at WFBR in Baltimore and XETRA, Tijuana. The proposal for 7.5-kHz spacing, CSSB, and shortwave stereo comes from Arthur Thompson of WYFR.

Stereo shortwave may be a long shot, and there are no consumer receivers designed for it yet. However, two separate receivers—one tuned to the upper sideband, one to the lower—would produce the effect. ◇

ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR MAR. & APR.

By Richard E. Wood

TO EASTERN NORTH AMERICA

TIME-EST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
6:00-6:25 a.m.	1100-1125	Tirana, Albania	F	9.48, 11.865
6:00-8:30 a.m.	1100-1330	London, England	G	5.99 (via Sackville), 6.195 (via Antiqua), 15.07
6:00-8:00 a.m.	1100-1300	Melbourne, Australia	G	9.58
6:00-9:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
6:05-7:25 a.m.	1105-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
6:30-9:00 a.m.	1130-1400	**Montreal, Canada (Northern Service)	G	5.96, 9.625 (includes French, etc.)
6:45-7:05 a.m.	1145-1205	**Montreal, Canada	G	9.56, 11.72
7:00-7:30 a.m.	1200-1230	Jerusalem, Israel	G	15.10, 17.815
7:00-7:55 a.m.	1200-1255	Peking, China	F	11.685
7:10-7:30 a.m.	1210-1230	**Santiago, Chile	F	9.566, 11.81, 15.15
7:15-7:30 a.m.	1215-1230	Athens, Greece	F	15.345, 17.83
		HCJB, Quito, Ecuador	G	11.745
7:30-8:00 a.m.	1230-1300	Stockholm, Sweden	G	15.305
7:30-11:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
8:15-8:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
8:30-9:00 a.m.	1330-1400	Helsinki, Finland	G	15.17
9:00-9:15 a.m.	1400-1415	**Montreal, Canada	G	15.325, 17.74
9:00-9:30 a.m.	1400-1430	Oslo, Norway	G	17.80 (Sun.)
		Stockholm, Sweden	G	15.305
9:00 a.m.-7:00 p.m.	1400-2400	**Montreal, Canada (Northern Service)	G	9.625, 11.72
9:30-10:00 a.m.	1430-1500	Helsinki, Finland	G	15.11
10:00-11:00 a.m.	1500-1600	London, England	G	17.84 (via Ascension), Sat., Sun. also 9.58 (via Sackville)
10:15-10:30 a.m.	1515-1530	Athens, Greece	P	11.73, 15.345, 17.83
11:00-11:15 a.m.	1600-1615	London, England	G	9.58 (via Sackville) 17.84 (via Ascension)
11:00-11:30 a.m.	1600-1630	Oslo, Norway	G	15.17 (Sun.)
11:15 a.m.-1:30 p.m.	1615-1830	London, England	G	9.58 (via Sackville)
12 noon-3:00 p.m.	1700-2000	**Kuwait, Kuwait	F	9.555, 11.845
12:04-12:56 p.m.	1704-1756	**Paris, France	G	15.155, 15.20, 15.30, 15.315, 17.72, 17.85, 17.865, 21.58, 21.62

1:00-1:30 p.m.	1300-1830	**Montreal, Canada	G	15.325, 17.82
1:30-2:00 p.m.	1830-1900	**Montreal, Canada	G	9.685, 11.855
2:00-2:30 p.m.	1900-1930	**Montreal, Canada	G	9.625, 11.83, 15.325, 17.82
2:00-3:00 p.m.	1900-2000	**Algiers, Algeria	F	9.78, 11.91, 15.42 (variable)
2:00-5:00 p.m.	1900-2200	**Jeddah, Saudi Arabia	F	11.855
2:30-3:00 p.m.	1930-2000	**Montreal, Canada	G	9.685, 11.855
3:00-3:30 p.m.	2000-2030	**Tehran, Iran	F	9.022, (11.77 alternate)
		Jerusalem, Israel	G	5.90, 7.395, 9.815
3:00-4:00 p.m.	2000-2100	Accra, Ghana	F	11.85
3:00-4:20 p.m.	2000-2120	**Hilversum, Holland	G	11.73 (via Talata)
3:50-4:50 p.m.	2050-2150	**Havana, Cuba	G	11.865, 17.75
4:00-4:50 p.m.	2100-2150	**Johannesburg, S. Africa	G	7.27, 9.585, 11.80, 11.90
4:00-5:00 p.m.	2100-2200	**Brasilia, Brazil	G	15.245 (11.78 alternate)
4:15-5:45 p.m.	2115-2245	London, England	G	9.58 (via Ascension), 11.78, 15.26 (via Ascension)
4:30-5:00 p.m.	2130-2200	Sofia, Bulgaria	F	6.07, 9.70
4:30-5:50 p.m.	2130-2250	Hilversum, Holland	G	9.715, 11.73 (Sun.: Dutch)
5:00-5:15 p.m.	2200-2215	**Belgrade, Yugoslavia	F	6.10, 7.24, 9.62
5:00-5:30 p.m.	2200-2230	**Montreal, Canada	G	5.925, 9.445
		Oslo, Norway	F	11.87 (Sun.)
		**Caracas, Venezuela	F	15.40 (varies, Mon.-Fri.)
5:00-6:15 p.m.	2200-2315	**Cairo, Egypt	G	9.805
5:00-7:30 p.m.	2200-0030	Ankara, Turkey	G	9.515, 11.88
5:30-6:00 p.m.	2230-2300	Jerusalem, Israel	G	7.412, 9.815, 11.645, 12.025
		Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.15, 7.205, 7.355, 7.40, 9.655, 9.72, 9.745, 11.77, 11.90
5:30-6:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.80, 11.90
5:45-11:30 p.m.	2245-0430	London, England	G	5.975, 7.325, 9.58 (via Ascension)
5:50-6:10 p.m.	2250-2310	**Santiago, Chile	P	9.566, 11.81, 15.15
6:00-6:30 p.m.	2300-2330	Stockholm, Sweden	F	6.045, 9.605, 11.705
		Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.15, 7.205, 7.355, 7.40
		Vilnius, U.S.S.R.		7.29, 7.32, 7.55, 9.655, 9.72, 9.745, 11.77 11.90 (Sat., Sun.)
6:00-6:50 p.m.	2300-2350	**Buenos Aires, Argentina	G	11.71 (Mon.-Fri.)
6:00-8:00 p.m.	2300-0100	Montreal, Canada	G	5.96 (Mon.-Fri.)
6:30-7:00 p.m.	2330-2400	Helsinki, Finland	P	11.755
		**Radio Clarin, S. Domingo, Dom. Rep.	G	11.70 (irregular)
6:30-7:30 p.m.	2330-0030	Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.15, 7.165, 7.205, 7.235, 7.355, 9.79, 9.80
6:45-7:00 p.m.	2345-2400	**Voice of Org. of American States Washington, USA	G	6.13, 9.64, 11.74
6:45-7:45 p.m.	2345-0045	Tokyo, Japan	F	15.27, 15.30
7:00-7:25 p.m.	0000-0025	Tirana, Albania	G	7.065, 9.75 (varies)
7:00-7:30 p.m.	0000-0030	Oslo, Norway	F	6.185 (Sun.)
7:00-7:55 p.m.	0000-0055	Sofia, Bulgaria	F	9.705 (alternate 9.70)
		Peking, China	F	11.945, 15.06, 15.52, 17.673
7:00-9:00 p.m.	0000-0200	**Luxemburg	F	6.09
7:00-8:00 p.m.	0000-0100	**VOA, Washington, USA	G	6.19, 9.67, 11.83, 11.895
7:00 p.m.-1:06 a.m.	0000-0606	**Montreal, Canada (Northern Service)	F	6.065, 9.625
7:15-7:30 p.m.	0015-0030	Athens, Greece	F	9.75, 9.76, 11.73
7:15-7:45 p.m.	0015-0045	Brussels, Belgium	F	9.725
7:30-7:55 p.m.	0030-0055	Prague, Czechoslovakia	F	6.055, 9.74
7:30-8:00 p.m.	0030-0100	Stockholm, Sweden	P	11.955
		Kiev, U.S.S.R.	G	7.15, 7.205,
		Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.355, 7.40, 7.44
7:40 p.m.-12 mdt.	0040-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
8:00-8:15 p.m.	0100-0115	Vatican, City	G	5.995, 6.015, 9.605
8:00-8:20 p.m.	0100-0120	Rome, Italy	G	6.01, 9.575
8:00-8:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.205, 7.355, 7.40, 7.44
		Vilnius, U.S.S.R.	G	7.15, 7.215, (Sat., Sun.)
		Montreal, Canada	G	9.535
8:00-8:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	P	9.73
8:00-8:55 p.m.	0100-0155	Peking, China	G	7.12, 9.78 (via Tirana), 11.685, 11.945, 15.06, 15.52
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74
8:00-10:00 p.m.	0100-0300	Melbourne, Australia	F	15.32, 17.795
8:00-10:30 p.m.	0100-0330	Havana, Cuba	G	11.725, 11.93
8:00-11:00 p.m.	0100-0400	Madrid, Spain	G	6.065, 11.88 (Mon.-Sat.)
8:10-8:30 p.m.	0110-0130	**Santiago, Chile	F	9.566, 11.81, 15.15
8:30-8:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.01, 6.04 (via Antigua), 6.075, 9.565, 9.605
8:30-8:55 p.m.	0130-0155	Tirana, Albania	G	6.20, 7.30
		Vienne, Austria	P	6.155, 9.77
8:30-9:00 p.m.	0130-0200	Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.15, 7.205, 7.215, 7.355, 7.40, 7.44, 9.705 (alt. 9.70 via Sofia)
8:30-9:25 p.m.	0130-0225	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
8:45-9:15 p.m.	0145-0215	Berne, Switzerland	G	5.965, 6.135, 9.725, 11.715

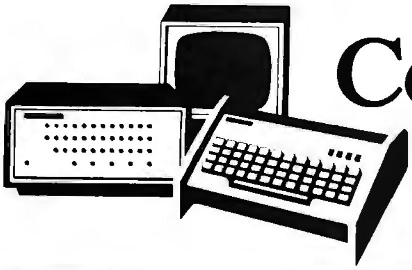
9:00-9:30 p.m.	0200-0230	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Exc. Sun.)
		Oslo, Norway	F	6.185 (Sun.)
		Montreal, Canada	G	6.065, 9.535
9:00-9:55 p.m.	0200-0255	Peking, China	F	11.965, 12.055, 15.06
9:00-10:00 p.m.	00-0300	Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.205, 7.355, 9.705 (alt. 9.70 via Sofia)
9:00-10:20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)
9:00-10:30 p.m.	0200-0330	Cairo, Egypt	G	9.475
9:10-9:30 p.m.	0210-0230	**Santiago, Chile	P	9.566, 11.81, 15.15
9:30-9:55 p.m.	0230-0255	Tirana, Albania	G	6.20, 7.30
9:30-10:00 p.m.	0230-0300	Lisbon, Portugal	F	6.025, 11.935
		Stockholm, Sweden	P	6.045, 9.695
10:00-10:30 p.m.	0300-0330	Budapest, Hungary	F	6.00, 7.215, 9.585, 9.833, 11.91
		Kiev, U.S.S.R.	G	7.15, 7.205, 7.24, 7.26, 7.40
10:00-10:35 p.m.	0300-0335	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
10:00-10:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana)
10:00-11:00 p.m.	0300-0400	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74
		Moscow, U.S.S.R.	G	5.94, 7.115, 7.355, 7.44
10:00-11:26 p.m.	0300-0426	**Johannesburg, S. Africa	F	3.995, 5.98, 7.27
10:10-10:30 p.m.	0310-0330	**Santiago, Chile	F	9.566, 11.81, 15.15
10:30-10:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
10:30-11:30 p.m.	0330-0430	London, England	G	5.975, 9.58 (via Ascension)
10:30-11:50 p.m.	0330-0450	Havana, Cuba	G	11.725, 11.76, 11.93
11:00-11:15 p.m.	0400-0415	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Tues., Fri.)
11:00-11:25 p.m.	0400-0425	Bucharest, Rumania	F	5.99, 6.155, 6.19, 9.57, 9.68, 11.775, 11.94
11:00-11:30 p.m.	0400-0430	Oslo, Norway	P	6.185, 9.61 (Sun.)
11:30 p.m.-2:30 a.m.	0430-0730	London, England	G	6.175 (via Antiqua)
11:50 p.m.-1:00 a.m.	0450-0600	Havana, Cuba	G	11.725, 11.76
12 mdt.-12:15 a.m.	0500-0515	Jerusalem, Israel	G	5.90, 7.412, 9.009
12 mdt.-2:00 a.m.	0500-0700	HCJB, Quito, Ecuador	G	6.05, 9.56

TO WESTERN NORTH AMERICA

TIME-EST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
3:00-3:15 a.m.	1100-1115	Tokyo, Japan	P	5.99
3:00-4:25 a.m.	1100-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
3:00-5:30 a.m.	1100-1330	London, England	G	5.99 (via Sackville), 11.75 (via Tebrau)
3:00-6:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
4:00-4:15 a.m.	1200-1215	Tokyo, Japan	P	5.99
4:00-4:30 a.m.	1200-1230	**Tashkent, U.S.S.R.	F	6.025, 9.60, 11.925
4:10-4:30 a.m.	1210-1230	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
4:15-4:30 a.m.	1215-1230	HCJB, Quito, Ecuador	G	11.745
4:30-6:00 a.m.	1230-1400	Trans-World Radio Bonaire, N.A.	G	15.255 (Sat., Sun.)
4:30-8:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
5:00-5:15 a.m.	1300-1315	Tokyo, Japan	P	5.99
5:30-7:00 a.m.	1330-1500	**Delhi, India	F	11.81, 15.345
6:00-6:30 a.m.	1400-1430	Tokyo, Japan	G	5.99
		**Tashkent, U.S.S.R.	F	9.60, 11.925
6:00-7:20 a.m.	1400-1520	**Hilversum, Holland	G	11.73 (via Talata)
6:00-8:55 a.m.	1400-1655	Manila, Philippines (VOP)	F	9.58 (Closes 1555 Sun.)
7:00-7:15 a.m.	1500-1515	Tokyo, Japan	G	5.99
7:00-8:00 a.m.	1500-1600	London, England	G	17.84 (via Ascension) Sat., Sun. also 9.58 (via Sackville)
8:00-8:15 a.m.	1600-1615	Tokyo, Japan	G	5.99
		London, England	G	9.58 (via Sackville), 17.84 (via Ascension)
8:15-10:30 a.m.	1615-1830	London, England	G	9.58 (via Sackville)
8:42-8:51 a.m.	1642-1651	Hilversum, Holland	G	11.82, 15.19 (via Bonaire, Mon.-Fri.)
9:00-9:15 a.m.	1700-1715	Tokyo, Japan	G	5.99
10:00-10:15 a.m.	1800-1815	Tokyo, Japan	G	9.505
10:00-10:30 a.m.	1800-1830	Oslo, Norway	F	11.895 (Sun.)
11:00-11:07 a.m.	1900-1907	**Papeete, Tahiti	F	11.825, 15.17 (exc. Sun.)
11:00-11:15 a.m.	1900-1915	Tokyo, Japan	G	9.505
11:00 a.m.-12 noon	1900-2000	Taipei, Taiwan	G	9.51, 11.86, 15.225
12 noon-12:15 p.m.	2000-2015	Tokyo, Japan	G	9.505
12 noon-1:20 p.m.	2000-2120	**Hilversum, Holland	G	11.73 (via Talata)
1:00-1:15 p.m.	2100-2115	Tokyo, Japan	G	9.505
1:15-3:00 p.m.	2115-2300	London, England	G	9.58 (via Ascension)
2:00-2:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
2:00-2:30 p.m.	2200-2230	**Caracas, Venezuela	F	15.40 (varies; Mon.-Fri.)
2:00-4:00 p.m.	2200-2400	**VOA, Washington, USA	G	17.82, 17.895, 21.61
2:30-3:00 p.m.	2230-2300	Jerusalem, Israel	F	7.412, 9.815, 11.645, 12.025
2:30-3:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.80, 11.90
2:30-4:30 p.m.	2230-0030	Moscow, U.S.S.R.	G	6.02, 7.26, 9.635, 9.78, 12.05, 15.14, 15.18, 15.455, 17.72

2:50-3:10 p.m.	2250-2310	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
3:00-3:30 p.m.	2300-2330	Tokyo, Japan	G	15.105
3:00-4:30 p.m.	2300-0030	London, England	G	6.175, 9.51 (via Sackville), 9.58 (via Ascension)
3:00-5:00 p.m.	2300-0100	Montreal, Canada	F	5.96
3:30-4:00 p.m.	2330-2400	**Radio Clarin, S. Domingo, Dom. Rep.	G	11.70 (irregular)
3:45-4:00 p.m.	2345-2400	**Voice of Org. of American States, Washington, USA	G	6.13, 9.64, 11.74
4:00-4:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
4:00-5:00 p.m.	0000-0100	**VOA, Washington, USA	G	11.83, 11.895, 15.40
4:30-5:00 p.m.	0030-0100	Moscow, U.S.S.R.	G	6.02, 7.26, 9.635, 9.78, 12.05, 15.14, 15.18, 15.455, 17.72
4:30-7:30 p.m.	0030-0330	London, England	G	6.175 (via Sackville), 9.51 (via Greenville), 9.58 (via Ascension)
4:40-9:00 p.m.	0040-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
5:00-5:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
5:00-5:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	6.02, 7.175, 9.635, 9.78, 12.05, 15.14, 15.18, 15.455
5:00-7:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
5:00-8:00 p.m.	0100-0400	Madrid, Spain	F	6.065, 11.88 (Mon.-Sat.)
5:10-5:30 p.m.	0110-0130	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
5:30-6:30 p.m.	0130-0230	Tokyo, Japan	G	15.195, 15.235, 17.725, 17.825
		Moscow, U.S.S.R.	G	6.02, 7.175, 9.635, 9.78, 11.86, 12.05, 15.14, 15.18, (to 0200), 15.455 (to 0200)
6:00-6:15 p.m.	0200-0215	Tokyo, Japan	G	15.105
6:00-8:00 p.m.	0200-0400	Taipei, Taiwan	F	9.685, 15.425, 17.89
6:10-6:30 p.m.	0210-0230	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
6:30-7:00 p.m.	0230-0300	Stockholm, Sweden	P	9.695, 11.705
		Moscow, U.S.S.R.	G	6.02, 7.26, 9.635, 9.78, 11.86, 15.14
7:00-7:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
7:00-7:30 p.m.	0300-0330	Kiev, U.S.S.R.	G	7.26, 9.58, 9.635, 9.78, 11.86
		Montreal, Canada	G	6.045, 6.065, 9.535, 9.655
7:00-7:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana), 11.445, 12.055, 15.06, 15.385, 17.735, 17.855
7:00-8:20 p.m.	0300-0420	**Johannesburg, S. Africa	F	3.995, 7.27, 9.58
7:10-7:30 p.m.	0310-0330	**Santiago, Chile	F	6.195, 9.566, 11.61, 15.15
7:20-8:25 p.m.	0320-0425	**TIFC, San Jose, Costa Rica	F	6.035, 9.645, (opens 0300 Sat., Sun.)
7:22-7:28 p.m.	0322-0328	Erevan, U.S.S.R.	G	6.02, 9.54, 9.735, 11.69, 15.14 (Sat./Tue./Wed./Fri.)
7:30-8:00 p.m.	0330-0400	Moscow, U.S.S.R.	G	6.02, 7.26, 9.54, 9.58, 9.635, 9.735, 9.78, 11.69, 15.14
7:30-8:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	P	5.955, 6.08, 9.56, 9.73
7:30-8:30 p.m.	0330-0430	London, England	G	6.175 (via Sackville), 9.58 (via Ascension)
8:00-8:15 p.m.	0400-0415	Tokyo, Japan	G	15.105
8:00-8:30 p.m.	0400-0430	Sofia, Bulgaria	F	9.705 (alt. 9.70)
		Budapest, Hungary	F	6.00, 7.215, 9.585, 9.833, 11.91 (Tue., Fri.)
		Montreal, Canada	G	6.045, 9.655
8:00-9:00 p.m.	0400-0500	Moscow, U.S.S.R.	G	602, 7.175, 7.26, 9.54, 9.58, 9.61 (from 0430), 9.635, 9.735, 9.78, 11.69
8:30-9:00 p.m.	0430-0500	Berne, Switzerland	G	6.045, 9.725
8:30-11:30 p.m.	0430-0730	London, England	G	6.175 (via Antiqua)
9:00-9:15 p.m.	0500-0515	Jerusalem, Israel	F	5.90, 7.395, 7.412
		Tokyo, Japan	G	9.505
9:00-9:30 p.m.	0500-0530	Lisbon, Portugal	F	6.025, 11.935 (varies)
9:00-10:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715, (via Bonaire)
9:00-11:00 p.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
9:00-11:30 p.m.	0500-0730	Moscow, U.S.S.R.	G	6.02, 7.175, 7.26, 9.54, 9.58, 9.61, 9.635, 9.735, 9.78
9:30-9:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	G	5.96 (via Antiqua) 6.10 (via Malta), 6.185, 9.545
10:00-10:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
10:00-10:30 p.m.	0600-0630	Oslo, Norway	F	9.645, 11.87 (Sun.)
10:00-11:00 p.m.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
10:00 p.m.-12 mdt.	0600-0800	Pyongyang, Dem. Rep. Korea	G	9.82
10:30 p.m.-12:30 a.m.	0630-0830	Havana, Cuba	G	9.525
10:45 p.m.-12:45 a.m.	0645-0845	**Wellington, N.Z.	F	11.78
11:00-11:15 p.m.	0700-0715	Tokyo, Japan	G	9.505
12 mdt.-12:15 a.m.	0800-0815	Tokyo, Japan	G	9.505
12 mdt.-2:00 a.m.	0800-1000	Manila, Philippines (FEBC)	F	11.92
1:00-1:15 a.m.	0900-0915	Tokyo, Japan	G	9.505
2:00-2:30 a.m.	1000-1030	Tokyo, Japan	G	5.99

*Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor
**Not intended for North America, but receivable satisfactorily
Days refer to local date in target area.



Computer Bits

By Hal Chamberlin

MEMORY TESTING

IT'S LATE at night and you have just finished assembling an expansion memory board for your computer. You turn the computer on and operate the console. It seems to function OK. Now it's time to run a memory test program to make sure that every one of those 4096 new bytes can store and recall data reliably.

A good memory test routine should be able to detect all possible failure modes on the new board. When used at home, it can be run continuously for a day or two to "burn in" the components and detect early failures while the warranty is still in effect. The CPU, data busses, and power supply are also exercised proving their ability to handle the additional load. In a small business application it may be wise to run a memory test (and tests of other system components as well) before processing sensitive financial data.

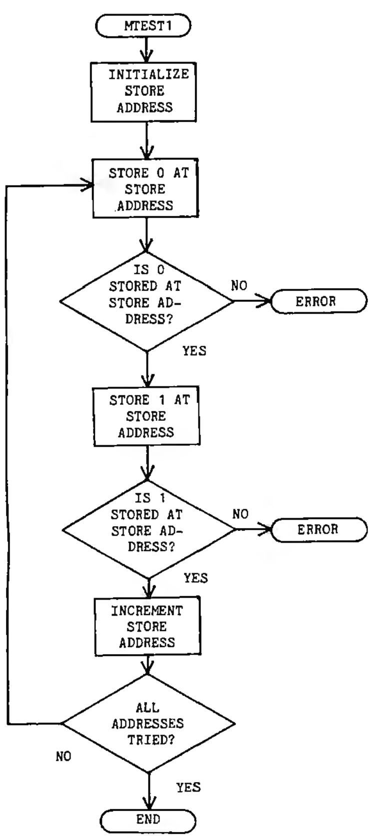


Fig. 1. Simple memory test.

A Simple Test Program. Basically a test of memory amounts to checking that each memory byte will correctly read back previously stored data. Since each byte is in turn composed of 8 bits, the data used for checking should try each bit in the "1" and "0" states. Thus a simple test procedure might be first to write all zeroes into a byte, read it back for checking, try all ones, and then go to the next address until all 4096 bytes are tested. Figure 1 shows a flowchart of such a test routine. Actually this is a very poor testing scheme because it will fail to detect a number of common memory board faults.

Shorts between two closely spaced printed circuit traces is a common problem. Assume a solder bridge short between two adjacent data lines on the board. What this means is that those two bits will always be read back identical to each other regardless of what is actually stored in the memory IC's. Usually zeroes will override; meaning that if either of the "paired" data lines has a 0, it will force the other one to a 0 also. Obviously the test scheme in Fig. 1 would not detect this problem since all bits in the byte are identical. Other complementary patterns such as 252 (10101010) and 125 (01010101) (octal) could be used but no such pattern can guarantee detection of a short between *any* pair of data lines.

Shorts or opens in the large number of parallel address lines are even more likely and would not be detected either. The effect of most address line problems is that the actual number of distinct storage locations is less than the 4096 it should be. Another way to think of this is that two or more *different* addresses will refer to the *same* memory cell. Since the routine uses the same data in each location and only one location at a time is checked, it would probably run OK even if *none* of the address lines worked! About the only circuitry this routine does test is the data buffers (if the board has them) and whatever memory cells that can be addressed correctly.

A Better Test Program. Let us try to design a better testing scheme that detects the common faults noted above. To solve the problem of detecting shorted data lines, we should try to store and recall all 256 possible 8-bit numbers. To detect bad address lines, we should look at all of the other addresses to make

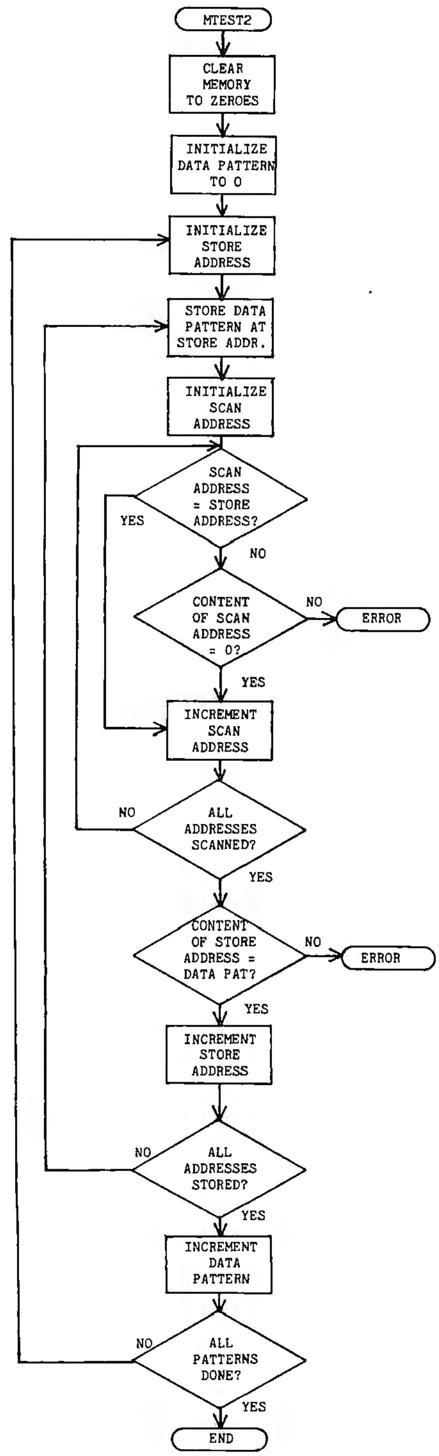


Fig. 2. Better memory test.

sure the data just stored does not pop up someplace else. Figure 2 shows a flowchart for this more effective test procedure. An estimate of the test execution time can be obtained by multiplying the execution time of the inner loop by 4096 locations times 256 data patterns. On a full-speed 8080 this is about 35 microseconds X 4096 X 4096 X 256 or nearly two days!

This routine is quite effective in locating memory board problems but cannot detect a fairly common (though less so now than in the past) memory *chip* problem that is termed "pattern sensitivity". This is caused by a sort of "spillover" of bits into their neighbors on the chip and only causes problems with certain patterns of bits. From the memory chip's point of view this routine writes a single "1" bit in a sea of zeroes and checks that the "1" remains stored and that none of the zeroes is disturbed. As the test progresses, the "1" moves around until all locations are tested. Trying all possible bit patterns is not a feasible solution since there are 2^{1024} of them or about 10^{308} on a typical memory IC. It is possible to make a thorough test of pattern sensitivity in a reasonable time but a detailed knowledge of the particular memory chip's geometry is required.

Using Random Numbers. let us now take a look at how computer-generated random numbers can be used in an even better memory test program. Proper functioning of the data and address circuitry can be simultaneously tested by changing the procedure a little and using random data patterns. Instead of testing one location at a time we will first store data in all of the locations to be tested (the store phase) and then come back and see if all of the locations held their data (the verification phase). Also instead of using the same data in all locations, different random numbers will

(Text continued on p 110)

Fig. 3

```
                            *      MEMORY TEST PROGRAM USING RANDOM NUMBERS
                            *      WRITTEN FOR A 4K BLOCK OF MEMORY ON A 4K BOUNDARY

000:000 061 000 001  MTEST  LXI  SP,400Q              INITIALIZE STACK POINTER
000:003 041 001 000         LXI  H,1                  INITIALIZE RANDOM NUMBER SEED
000:006 315 130 000  PASS   CALL RAND                 NEW PASS, GET A RANDOM NUMBER IN HL
000:011 042 157 000         SHLD SEED                 SAVE AS SEED FOR VERIFY
000:014 021 000 020         LXI  D,4096               INITIALIZE ADDRESS COUNTER
000:017 315 130 000  STORPH CALL RAND                 GET A RANDOM NUMBER IN HL
000:022 315 111 000         CALL MADDR                FORM MEMORY ADDRESS IN BC
000:025 175                 MOV  A,L                  STORE RANDOM BYTE IN MEMORY
000:026 002                 STAX B                    AT ADDRESS IN BC
000:027 033                 DCX  D                    DECREMENT ADDRESS COUNTER
000:030 173                 MOV  A,E                  TEST IF IT IS ZERO
000:031 262                 ORA  D
000:032 302 017 000         JNZ  STORPH               CONTINUE STORE PHASE IF NOT
000:035 052 157 000         LHLD SEED                 RESTORE RANDOM SEED FOR VERIFY PHASE
000:040 021 000 020         LXI  D,4096               INITIALIZE ADDRESS COUNTER
000:043 315 130 000  VERFPH CALL RAND                 GET A RANDOM NUMBER IN HL
000:046 315 111 000         CALL MADDR                FORM A MEMORY ADDRESS IN BC
000:051 012                 LDAX B                    GET DATA FROM MEMORY
000:052 275                 CMP  L                    COMPARE WITH WHAT WAS STORED
000:053 302 067 000         JNZ  ERRLOG               GO TO ERROR LOG IF NOT THE SAME
000:056 033                 DCX  D                    DECREMENT ADDRESS COUNTER
000:057 173                 MOV  A,E                  TEST IF IT IS ZERO
000:060 262                 ORA  D
000:061 302 043 000         JNZ  VERFPH               CONTINUE TEST PHASE IF NOT
000:064 303 006 000         JMP  PASS                 GO FOR ANOTHER PASS
000:067 062 161 000  ERRLOG STA  WAS                  STORE ERRONIOUS DATA IN ERROR LOG AREA
000:072 175                 MOV  A,L
000:073 062 162 000         STA  SHLDBE               STORE CORRECT DATA
000:076 170                 MOV  A,B
000:077 062 164 000         STA  ERADDR+1             STORE ADDRESS OF ERROR
000:102 171                 MOV  A,C
000:103 062 163 000         STA  ERADDR
000:106 166 000 000         HLT                       HALT OR JUMP TO ERROR PRINT

                            *      SCRAMBLED MEMORY ADDRESS FORMATION ROUTINE
                            *      USES ADDRESS COUNTER IN DE AND RANDOM NUMBER IN SEED
                            *      TO FORM A SCRAMBLED ADDRESS IN BC

000:111 072 157 000  MADDR  LDA  SEED                 GET LOWER BYTE OF RANDOM NUMBER
000:114 253                 XRA  E                    EXCLUSIVE-OR WITH LOWER ADDRESS
000:115 117                 MOV  C,A
000:116 072 160 000         LDA  SEED+1               GET UPPER BYTE OF RANDOM NUMBER
000:121 252                 XRA  D                    EXCLUSIVE-OR WITH UPPER ADDRESS
000:122 346 017             ANI  17Q                  SAVE ONLY 4 BITS FOR 4K MEMORY
000:124 306 xxx             ADI  (page number)        ADD IN FIRST PAGE NUMBER OF BOARD
000:126 107                 MOV  B,A                  BEING TESTED
000:127 311                 RET                       RETURN
```

Fig. 3 (Cont'd.)

```
                         *       RANDOM NUMBER GENERATOR SUBROUTINE
                         *       ENTER WITH SEED IN REGISTERS H AND L
                         *       EXIT WITH NEW RANDOM NUMBER IN H AND L
                         *       USES 16 BIT FEEDBACK SHIFT REGISTER METHOD
                         *       DESTROYS REGISTERS A AND B

000:130 006 010          RAND    MVI  B,8           SET COUNTER FOR 8 RANDOM BITS
000:132 174              RAND1   MOV  A,H           EXCLUSIVE-OR BITS 3,12,14, AND 15
000:133 017                      RRC                OF SEED
000:134 254                      XRA  H
000:135 017                      RRC
000:136 017                      RRC
000:137 254                      XRA  H
000:140 017                      RRC
000:141 255                      XRA  L             RESULT IS IN BIT 3 OF A
000:142 017                      RRC                SHIFT DOWN TO BIT 0 OF A
000:143 017                      RRC
000:144 017                      RRC
000:145 346 001                  ANI  1             CLEAR OUT ALL OTHER BITS
000:147 051                      DAD  H             SHIFT HL LEFT ONE
000:150 205                      ADD  L             REPLACE BIT 0 OF HL WITH RESULT
000:151 157                      MOV  L,A
000:152 005                      DCR  B             TEST IF 8 NEW RANDOM BITS COMPUTED
000:153 302 132 000              JNZ  RAND1         LOOP FOR MORE IF NOT
000:156 311                      RET                RETURN

                         *       STORAGE FOR MEMORY TEST

000:157                  SEED    DST  2             RANDOM NUMBER SEED SAVE
000:161                  WAS     DST  1             ERROR LOG AREA, ERRONIOUS DATA
000:162                  SHLDBE  DST  1             CORRECT DATA
000:163                  ERADDR  DST  2             ADDRESS OF ERROR
000:165                          END
```

be stored into each location. Finally, instead of storing and verifying in an ascending sequence of addresses, a scrambled sequence based on random numbers will be used.

One potential problem with this method is that, with true random numbers, it is not possible to tell during the verification phase what the stored data should be. One solution would be to retain a copy of the correct pattern in known good memory. A better solution is to use a "pseudo random" number generator. Such a generator works by creating a new number from an old one which is called the "seed." A sequence of random numbers is obtained by repeatedly calling the generator routine giving the last number it produced. If the same initial seed is used, then the sequence of random numbers will be the same. So we have to save only the seed to be able to regenerate the sequence for verification. A scrambled sequence of addresses can be obtained by exclusive OR'ing the lower 12 bits of the memory address with a random number that changes after each "pass" (store and verify phase) through the test routine. Also, after each pass, the data pattern seed is changed so that each pass is totally different.

Using this method the data lines will be thoroughly tested because after a short time all possible data bytes will have been tried. Addressing will be checked out also since an incorrect address during the data store phase is likely to wipe out data stored elsewhere earlier in the phase. The random address scrambling insures that a variety of pattern store sequences will be tried. After a few dozen passes through the routine, the likelihood is extremely high that every bit of memory has been tried in both one and zero states. Although pattern sensitivity of the memory chips is not specifically tested, a great variety of patterns will be tried.

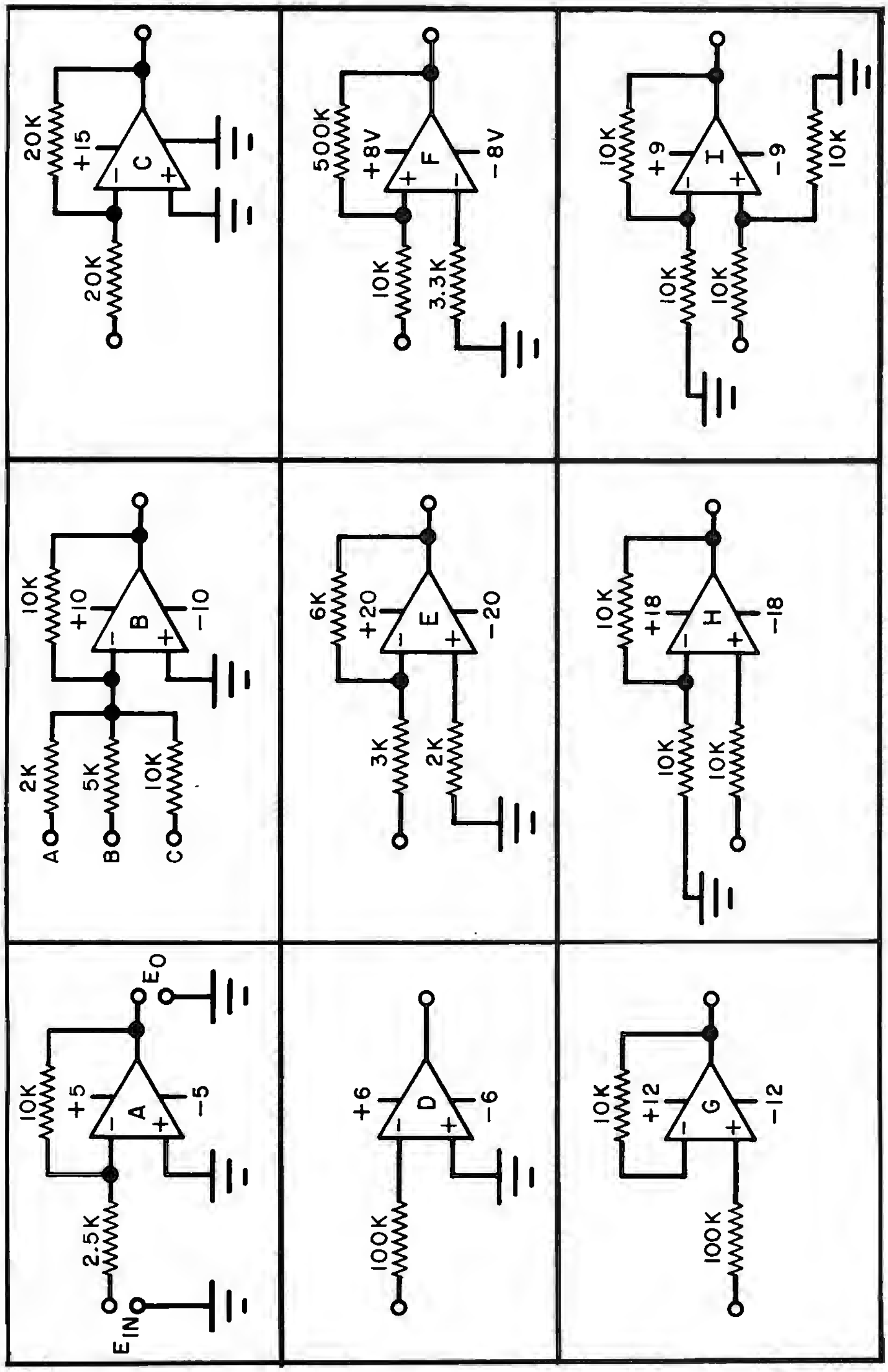
Figure 3 shows a listing of the improved memory test program in 8080 assembly language. The pseudo-random number generator subroutine simulates a 16-bit shift register with feedback for random bit generation (see the *TTL Cookbook* by Don Lancaster). Eight random bits are generated each call and are put together to make a random byte. The seed that is saved for the verify routine is also used as an address scrambler. The test program runs as an endless loop and will not repeat the sequence of addresses and patterns until 65,535 passes have been completed. Although written for testing a 4k byte memory board, it is readily modified for 8k and 16k boards also. If you are testing a so-called "dynamic" memory board, the computer should be periodically halted from the front panel for a few seconds. This will verify proper operation of the refresh circuitry since normal execution of the test routine would be sufficient to refresh the memory.

If an error is detected during the verify phase, control is passed to an error log routine. This routine stores the address of the error, the correct data byte, and the erroneous data byte in an error log area. (located at the end of the program). At this point, a print routine could take over for a permanent record of all errors. Otherwise, a simple halt could be executed allowing front-panel access to the error log area. By examining a number of error logs, it is usually possible to pinpoint the problem causing errors. For example, if only a single bit is in error and the errors are confined to a 1k block of addresses, then a bad memory chip is the probable cause. If there is a multitude of errors, and the correct data bears no resemblance to the wrong data, there is an addressing problem indicated. ◇

OPERATIONAL AMPLIFIER QUIZ

BY WILLIAM E. PARKER

Assume each of these circuits is an ideal op amp and each input is +1.0 volt dc. Determine the output voltages.



Answers A: −4; B: −8; C: 0; D: −6; E: −2; F: +8; G: +1; H: +2; I: +1.

Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, Popular Electronics, *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

Old Tubes W11, UV199, UV99, UV201A, UX201A,30 and VT-24-864. Needed for old radio collection. Tim Ding, 3752 Orange Ave., Long Beach, CA 90807.

Shaevitz Model S16A oscilloscope. Need manual and schematics. Gerald Kauffman, 99020 Nohua Pl., Aiea, HA 96701.

Tokyo Transistor Model MT-501A candle TV. Schematic, service manual or parts. Bernie J. Workman, 730 Jefferson Ave., Huntington, W. VA 25704.

Electromec Model 1720 oscilloscope. Schematic, operating and maintenance manuals. Perry C. Hutchison, 237 Sheldon, Ames, IA 50010.

Mattes Model SSP-200 stereo power amplifier. Need schematic. G.D.C., Box 824, Huntsville, AL 35804.

Smith Florence Model 810 I-R-E meter. Need manual and schematic. John R. McDaniel, R. R. #1, Box 218, Spencer, IN 47460.

Atwater Kent Model 812 radio. Need schematic and parts list. P. A. Seuferer, 706 New Castle Rd., Marshalltown, IA 50158.

Pentron Model T-90 reel-to-reel tape recorder. Need drive belts and instruction manual. John Whybrew, P. O. Box 387, Upland, IN 46989.

Picture Tube type 13AP4. Need Source. Bob Dvorak, 6244 Colby, Lincoln, NE 68505.

Hammarlund Model HQ 170 ham band receiver. Schematic, calibration and maintenance information needed. Bill Bruyn, 13 Sullivan Ave., Ottawa, ONT,K2G 1S8 Canada.

Hallicrafters Model S-40A shortwave receiver. Schematic and instruction manual. Robert R. Lintner, 102 Cherry St., Gnadenhutten, OH 44629.

Burroughs Model E3500 computer. Operating and programming instructions needed. Frank Hoszu, 725 Wiagara Ln., Wayzata, MN 55391.

Supreme Model 546 oscilloscope. Schematic and manual needed. Peter Pellerzi, 34-45 28th St., Astoria, NY 11106.

Acoustech Model XI stereo power amplifier. Schematic, voltage chart and manual. William Lourie, 2444 White Rd., Cleveland, OH 44118.

Westinghouse Model H-161 AM/FM radio. Schematic and service manual needed. Frank Holland, 17 Hilltop Trailer Ct., Fairfax, VA 22030.

Navy type CCT-46217 radio receiver. Schematic, service information and operating manual needed. Ed Grimes, 569 N. Main Republic, MO 65738.

DeVry transistorized automotive analyzer. Manual or schematic needed. Stanley G. Boler, 116 S. Washington St., Knightstown, IN 46148.

Guided Radio Corp. Model M-116A battery powered megaphone set. Need schematic and one 1J6 tube. Dwayne Pantle, Rte. 2, Box 131-C, Woodburn, OR 97071.

Superior Instrument Model TV-50A genometer. Schematic and/or service manual. Dennis Arvisais, 71 Plymouth St., New Bedford, MA 02740.

Packard Bell Model 920, "Sync-Lok" TV camera. Schematic and manual needed. Mr. Terry D. Caster, 6515 Hunters Ridge, Holly, MI 48442.

Precision Model 120 V.O.M. Meter movement needed. Gary Lawson, 128 Poillon Ave., Staten Island, NY 10312.

Knight Model C-22 Citizens Band transceiver. Construction and operating manual needed. Robert W. Boehnke, 3011 Antioch Rd., Perry, OH 44081.

McMurdo Model 911 silver sweep generator. Need schematic and maintenance information. John Zetlmeier, 29 Coolidge St., Haverstraw, NY 10927.

Hammarlund Model CB214 CB transceiver. Schematic needed. Joe Dura, 2910 Red Fox Run, Warren, OH 44485.

Electronics Library

DIGITAL TROUBLESHOOTING

by Richard E. Gasperini

The heart of this book is in three chapters. The first covers tools such as logic probes and comparators, and techniques such as piggy-backing IC's, selective shotgunning, toothpicking, and "smoking it out." The chapter on logical troubleshooting examines ways of localizing the problem, including half-splitting and the serial method. The third shows how to remove IC's, with vacuum devices, combination irons, and desoldering wick. The other 15 chapters offer background material (numbering systems, how IC's are manufactured, obtaining parts, logic symbols) or describe various circuits and show how to troubleshoot them (bipolar IC's, MOS, flip-flops, counters, shift registers, displays, memories, etc.). An appendix shows how to decode IC manufacturers' type numbers.

Published by Movonics Co., distributed by Hayden Book Co., 50 Essex St., Rochelle Park, NJ 07662. 180 pages. $9.95 soft cover.

MICROCOMPUTER DESIGN

by Donald P. Martin

Published by the manufacturers of the Mike 3 and Mike 8 hobby microcomputers, this handbook goes into great detail on the 8008 and 8080 microprocessors. After comparing them with several other popular MPU's, the author examines timing, bus structures, input/output instructions, RAM and ROM, DMA, interrupts, timers, digital displays, interfacing, keyboards, analog I/O, software, and testing. The book concludes with two minimal micros, using 9 and 19 chips, and a thorough discussion of the CPU board for the Mike 3.

Published by Martin Research, 3336 Commercial Ave., Northbrook, IL 60062. 416 pages. $25 soft cover.

THE RADIO AMATEUR'S HANDBOOK

by Robert Hertzberg, revised by A. Frederick Collins

First published in 1964, this well-known handbook is now in its 13th edition. New chapters have been added on CB radio and 2-meter fm equipment. There are chapters on vacuum tubes and solid-state devices, construction techniques, power supplies, receiver and transmitter theory, amateur licenses, antennas, mobile operation, test equipment, and setting up and operating an amateur station.

Published by Thomas Y. Crowell Co., 666 Fifth Ave., New York, NY 10019. 378 pages. $8.95 hard cover.

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by John L. Hilburn and Paul M. Julich

Part of the extensive Prentice-Hall series on automatic computation, this lean-meat text requires no formal training in digital logic. The first three chapters provide the needed background in basic elements, logic, and number systems. Next discussed are microcomputer hardware (ROM, read/write memory, microprocessors), software (machine, assembly and high-level languages), and interfacing to peripheral devices. Ten microprocessors are discussed in detail (with instruction sets given in the appendixes), and the final chapter is on design and applications.

Published by Prentice-Hall, Englewood Cliffs NJ 07632. 372 pages. $16.50 hard cover.

SOLID-STATE ELECTRONICS

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Published by Van Nostrand Reinhold Co., 450 West 33 St., New York, NY 10001. 202 pages. $8.95 hard cover.

MODERN GUIDE TO DIGITAL LOGIC: PROCESSORS, MEMORIES & INTERFACES

by United Technical Publications, Inc.

The first four chapters of this guide are on Schottky TTL, ECL and MECL logic gates, at a fairly high technical level. More complex circuits, such as adders and multipliers, accumulators and counters are taken up in the next two chapters, on the MECL 10,000 family, and MSI/LSI Schottky TTL. After a chapter on high-noise-immunity logic gates, and one on using and interfacing CMOS, the book ends with a short chapter on microprocessors and a longer one on bipolar and MOS memory (RAM and ROM). Most of the material in the book is taken from seminars, technical papers and data provided by Motorola, Texas Instruments, Intel, Teledyne Semiconductor, etc.

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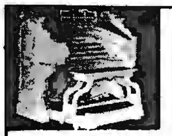

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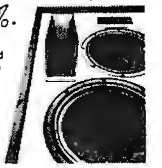

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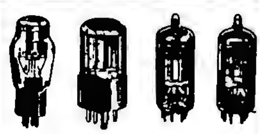

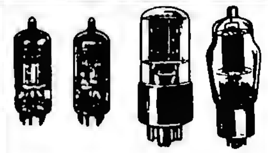

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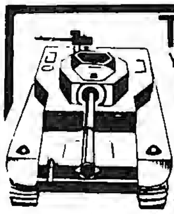

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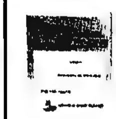

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COMMUNICATIONS Publications and Frequency Lists. Military, Government, Police, Aviation, Maritime and more. Catalog 25 cents. Handler, Box CC, Northfield, Ill. 60093.

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☐ 1-5 ☐ 11-15 ☐ over 20

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61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
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46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
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76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
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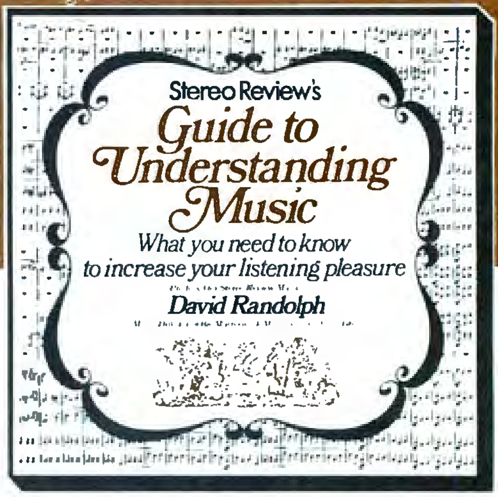

This unique four-disc album is interesting, easy to comprehend, and instructive. It is the first project of its kind to approach the understanding of music through its basic elements:
rhythm . . . melody . . .
harmony . . . texture.

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The GUIDE TO UNDERSTANDING MUSIC contains

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FREE BOOKLET INCLUDED. The accompanying booklet is a valuable complement to the album. It presents David Randolph's straightforward professional approach to music, and shares the insights and understanding of his many years of experience in bringing music to listeners . . . as well as advice on how you can make the best use of the album.

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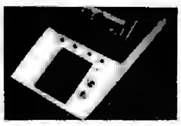

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12 OR 24-HOUR OPERATION
12 VOLT AC or DC POWERED FOR FIXED OR MOBILE OPERATION.
MODEL #2001
SIX LARGE .4" DIGITS!
Approx. Size: 1¾"H x 4"W x 4½"D

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
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- TOP QUALITY PC BOARDS & COMPONENTS - EXCELLENT INSTRUCTIONS
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A complete Kit less Cabinet featuring six .5" digits, MM5314 IC, 12/24 Hr. time, 50/60 HZ., Plug Transformer, Line Cord, Switches and all Parts. (Ideal Fit in Cabinet II) Kit # 5314-5 WITH PC Boards $19.95 ea. 2/$38.

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Convert small digit LED clock to large .5" displays. Kit includes 6 - .5" LED's, Multiplex PC Board & easy hook up info.
Kit # JD 1CC For common Cathode
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Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.
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7-SEG LED

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DL 750	RED	.6"	LHDP	$2 95
XAN [illegible]	GREEN	6"	NDP	$1.95
XAN [illegible]	RED	6"	NDP	$1 95

COMMON ANODE

	COLOR	HT	DEC PT.	PR EA
DL 747	RED	.6"	LHDP	$1 95
XAN 72	RED	3"	LHDP	$1.25
MAN 72	RED	3"	LHDP	$1 25
XAN 81	YELLOW	3"	RHDP	$1 75
XAN 351	GREEN	3"	RHDP	$1 50
XAN 361	RED	3"	RHDP	$1 50
XAN 362	RED	3"	LHDP	$1 50
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25 AMP BRIDGE
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PINS	1-24	25	100
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16	28	25	23
18	.31	.28	.26
24	.50	.45	.40
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Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC. 1"x2" PC Board Power Req: 5-15V (2.5 MA. TYP.) Easy 3 wire hookup Accuracy: ± 2PPM
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- 6 Big .4" digits
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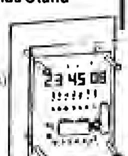

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$16.95 KIT

You requested it! Our first DC operated clock kit. Professionally engineered from scratch to be a DC operated clock. Not a makeshift kluge as sold by others. Features: Bowmar 4 digit .5 inch LED array, Mostek 50252 super clock chip, on board precision time base, 12 or 24 hour real time format, perfect for cars, boats, vans, etc. Kit contains PC Board and all other parts needed (except case). 50,000 satisfied clock kit customers cannot be wrong!

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STICK IT! in your clock in your DVM, etc.!

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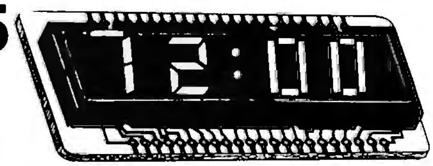

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The Bowmar Opto-Stick. The best readout bargain we have ever offered. Has four common cathode jumbo digits with all segments and cathodes brought out. Increased versatility since any of the digits may be used independently to fit your applications. Perfect for any clock chip, especially direct drive units like 50380 or 7010. Also use in freq. counters, DVM's, etc. For 12 or 24 hour format.

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KIT FEATURES:

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TIME IS OF THE ESSENCE!

And so is power. Not only are our RAM'S faster than a speeding bullet but they are now very low power. We are pleased to offer prime new 21L02—1 low power and super fast RAM's. Allows you to STRETCH your power supply farther and at the same time keep the wait light off. 8 for $12.95

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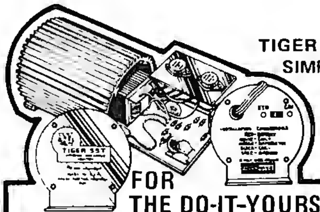

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7413	.43	7483	.68	74166	1.25
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7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74171	.84
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7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
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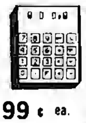

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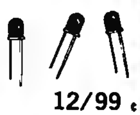

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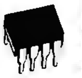

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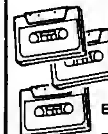

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7404	.21	7451	.27	74125	.60
7405	.24	7453	.27	74126	.81
7406	.45	7454	.41	74132	3.00
7407	.45	7460	.22	74141	1.15
7408	.25	7472	.39	74150	1.10
7409	.25	7473	.45	74151	1.25
7410	.20	7474	.45	74153	1.35
7411	.30	7475	.80	74154	1.25
7413	.85	7482	1.75	74155	1.21
7416	.43	7483	1.15	74157	1.30
7417	.43	7485	1.12	74161	1.45
7420	.21	7486	.45	74164	1.65
7422	1.50	7489	2.49	74165	1.65
7425	.43	7490	.89	74166	1.70
7427	.37	7491	1.20	74174	1.95
7428	.33	7492	.82	74175	1.95
7430	.26	7493	.82	74180	1.05
7432	.31	7494	.91	74181	3.55
7437	.47	7495	.91	74191	1.50
7438	.40	7496	.91	74195	1.00
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74H00	.33	74H11	.33	74H53	.39
74H01	.33	74H20	.33	74H55	.39
74H04	.33	74H21	.33	74H73	.59
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4010AE	.58	4026AE	1.49
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MC1558	4.37	MC14512CP	1.92
MC1595L	6.25	MC14519CG	.94
MC1596G	3.31	MC14528CP	1.74
MC1723CG	1.25	MC4044P	4.80

JAPANESE CIRCUITS

AN136	2.90	HA1312	4.05	STKO56	11.35	TA7201P	6.40
AN203	3.75	HA1322	5.20	STK415	11.50	TA7203P	7.00
AN208	4.75	HA1339	5.20	TA7045M	3.50	TA7204P	6.50
AN210	3.10	LA1201	4.25	TA7054P	3.05	TA7205P	6.50
AN211	3.30	LA1364	4.70	TA7055P	5.50	TA78005M	2.50
AN214	4.90	LA1366	6.00	TA7060P	1.85	TA78005P	1.95
AN217	3.30	LA1367	5.90	TA7061P	2.25	TA78012M	2.50
AN229	6.35	LA3301	4.85	TA7062P	2.25	TA78012P	1.95
AN234	5.75	LA4030	4.85	TA7063P	2.25	TA78015M	2.50
AN239	6.50	LA4031P	3.50	TA7074P	4.90	TA78015P	1.95
AN241	3.20	LA4051P	4.65	TA7075P	4.90	TC9100P	12.00
AN245	6.50	LD3001	3.35	TA7076P	4.55	UPC16C	2.50
AN274	3.95	LD3080	4.00	TA7092P	6.50	UPC20C	5.00
AN277B	3.40	LD3120	3.10	TA7102	5.15	UPC41C	3.95
AN288	4.80	LD3141	2.40	TA7106P	3.25	UPC48C	3.95
AN328	4.05	M5112	5.40	TA7120P	2.20	UPC554C	3.90
AN343	3.90	M5115PR	4.80	TA7120P-C	2.20	UPC563H2	8.00
BA511	3.50	M5155	2.85	TA7122AP	2.30	UPC566H	2.25
BA521	3.95	SG613	5.40	TA7124P	1.85	UPC575C	4.10
HA1158	6.30	STK011	10.50	TA7146P	4.10	UPC1001H2	5.15
HA1159	6.60	STK015	6.50	TA7150P	4.55	UPC1020H	5.50
HA1202	3.10	STK025	12.50	TA7153P	6.90	UPC1025	5.50
HA1306W	5.20	STK032	14.20	TA7200P	6.25		

MISC CIRCUITS

BC184L	.60	LM309K	1.95	SN15844N	.55
CA3001	.75	LM351AN	.70	SN15946	.55
CA3005	.80	LM741CP	.40	SN158097N	.60
CA3006	1.10	LM1458M	.65	SN72580P	4.50
CA3018	1.60	MFC9020	1.15	SN727410N	.85
CA3018A	1.60	MR995A	1.05	SN72741C	.45
CA3026	2.15	MSC9967P	1.50	SN72748P	.49
CA3035	2.45	N5558	.55	UA703C	.45
CA3039	1.35	N8598B	5.00	UA709C	.40
CA3058	1.90	NE555V	.45	USF7733393	2.40
CK707P	.45	PA771131	.45	995879	8.50
C5134J	1.15	PL994551	.45	996079	12.50
C5135J	1.20	RC14370B	.35	998979	9.00
C5136	1.25	SC9962P	.70	936-5D	1.10
IC3(GE)	1.50	SC9966P	1.25	9313DC	1.20
LM301AN	.35	SN15830N	.50	93L28DC	2.75

POSITIVE VOLTAGE REGULATORS

LM340K-5	1.95
LM340K-6	1.95
LM340K-8	1.95
LM340K-12	1.95
LM340K-15	1.95
LM340K-18	1.95
LM340K-24	1.95
LM340T0-5	1.75
LM340T0-6	1.75
LM340T0-8	1.75
LM340T0-12	1.75
LM340T0-15	1.75
LM340T0-18	1.75
LM340T0-24	1.75

NEGATIVE REGULATORS AVAILABLE

IC's ON THE MOVE

BBD : BUCKET BRIGADE DEVICE
MM3001 19.50 MN3002 11.70 MM3003 9.45
HALL IC : DN834 1.25 DN837 1.50
DN835 1.35 DN838(NEW)
SN76001 1.75 SN78002 1.95
PLL02A MIDLAND PHASE LOCK LOOP 12.00

MICROPROCESSOR CHIPS

1404A	3.25	2102	2.50	MM5013	3.25
C1702A	19.95	C2708	95.00	8008	19.95
2101	6.95	C4702A	19.95	8080A	29.95

MK4200 P-11	4096x1 Bit Dymanic Ram	9.95
C5101-3	1024 Bit (258x4) Static C-Mos Ram	4.50
MC14514	4 Bit Latch 4 to 16 Line Decoder	4.25

CALL OR WRITE FOR FURTHER INFORMATION, SPEC'S AVAILABLE

ELECTROLYTIC CAPACITORS

2.2MF50	AXIAL LEADS	.15
3.3MF10	AXIAL LEADS	.15
3.3MF10	NO POLARITY	.15
10MF25	AXIAL LEADS	.15
10MF50	AXIAL LEADS	.15
10MF150	AXIAL LEADS	.20
25MF35	AXIAL LEADS	.15
30MF25	AXIAL LEADS	.15
47MF25	RADIAL LEADS	.15
47MF50	RADIAL LEADS	.20
100MF16	RADIAL LEADS	.15
100MF25	RADIAL LEADS	.20
500MF50	AXIAL LEADS	.60
1000MF35	AXIAL LEADS	.65

CARBON RESISTORS
Minimum 5 Pc's Per Value

QUANTITY PRICING	5-25	30-95	100-495
¼w5%	.06	.05	.04
½w5%	.08	.07	.06

STANDARD RESISTANCE VALUES OHMS

10	270	820	4.7K	27K
22	300	910	5.1K	33K
47	330	1.0K	6.8K	47K
51	470	1.5K	7.5K	100K
100	510	2.2K	8.2K	330K
150	560	2.7K	10K	1.0M
220	680	3.3K	15K	
240	750	3.9K	22K	

HOBBY SPECIALS

YOU TEST 'EM $AVE BIG MONEY

Power Pac	100 Asst. (includes Case T03, T066 T0220, T0202)	$2.99
Transistor/ Diode Pac	100 Asst. (includes Case T05, T039, T018, D07, 0041)	$1.99
I.C Pac	100 Asst (includes 14 & 16 Pin)	$3.50
Resistor Pac	50 Asst. (Assorted values)	$1.50
Mos Fet Pac	10 Asst. (many top #'s Case T072)	$0.99
SCR Pac	100 Asst. (similar to C103 Series) Case to 92, VR:10-100V, I:400MA. IGT:200MA	$4.00

ZENER DIODES
½ & 1 Watt 10% .30 each UP TO 33V.
GREATER THAN 33V CALL FOR PRICING

PACE/PATHCOM PART #'S

130079	4.00	IP20-0123	2.75
1300821	.85	IP20-0131	2.50
13-0122	1.75	IP20-0141	3.00
83-0005	2.00	IP20-0142	3.00
83-0007	2.50	IP20-0139	.43
83-0008	2.00	IP20-0154	6.00
83-0015	3.00	IP20-0155	2.50
IP20-0005	3.00	IP20-0161	4.00
IP20-0016	.40	IP20-0177	2.75
IP20-0034	.85	IP20-0176	2.85
IP20-0037	.85	IP20-0191	.72
IP20-0045	2.00		
IP20-0073	2.75		
IP20-0093	2.50		

POPULAR JEDEC SEMICONDUCTORS

1N34	.25	2N918	.60	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45
1N60	.25	2N930	.25	2N2218A	.30	2N2907	.25	2N3730	2.50	2N4234	.95
1N270	.40	2N956	.30	2N2219	.25	2N2907A	.30	2N3731	3.75	2N4400	.16
1N914	.07	2N960	.90	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.18
		2N962	.95	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.18
2N173	1.75	2N967	.95	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N174	3.50	2N1136	1.75	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.16
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.40	2N4410	.16
2N327A	1.15	2N1300	1.00	2N2223	1.00	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1301	1.10	2N2270	.40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	.90	2N1302	1.25	2N2323	1.00	2N3227	1.00	2N3686	.85	2N5084	.50
2N338A	1.05	2N1303	.70	2N2324	1.35	2N3247	3.40	2N3903	.16	2N5130	.20
2N398B	1.50	2N1304	1.25	2N2325	2.00	2N3250	.50	2N3904	.16	2N5133	.15
2N404	.75	2N1305	.75	2N2326	2.85	2N3375	6.50	2N3905	.18	2N5138	.15
2N443	2.50	2N1308	1.35	2N2327	3.80	2N3393	.20	2N3908	.16	2N5198	3.75
2N456	1.30	2N1307	.75	2N2328	4.25	2N3394	.17	2N3925	3.75	2N5294	.50
2N501A	3.00	2N1308	1.50	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5296	.50
2N508A	.45	2N1309	.90	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	.75	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5354	.20
2N652A	1.25	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5369	.20
2N677	6.00	2N1557	1.15	2N2712	.18	2N3442	1.65	2N4036	.75	2N5400	.40
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5401	.50
2N706B	.75	2N1605	.35	2N2903	3.30	2N3583	.20	2N4093	.85	2N5457	.35
2N711	.90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1.10	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.16	CIO3Y	.25
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	C106B1	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.20	2N4142	.20		
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.20	2N4143	.20		

JAPANESE TRANSISTORS ★ CB, AUDIO, INDUSTRIAL

2SA52	.60	2SC206	1.00	2SC774	1.75	2SC1173	.95	2SD77	1.00
2SA316	.75	2SC240	1.10	2SC775	2.75	2SC1175	.65	2SD81	3.25
2SA473	.75	2SC291	.65	2SC776	3.00	2SC1209	.55	2SD88	1.50
2SA483	1.95	2SC292	3.00	2SC777	4.00	2SC1213	.75	2SD118	3.25
2SA489	.80	2SC320	.75	2SC778	4.00	2SC1226A	1.25	2SD130	1.25
2SA490	.70	2SC352	.75	2SC781	3.00	2SC1237	4.50	2SD141	2.25
2SA505	.70	2SC353	.75	2SC783	1.00	2SC1239	4.00	2SD151	2.25
2SA564	.50	2SC371	.70	2SC784	.70	2SC1243	1.50	2SD170	2.00
2SA628	.65	2SC372	.70	2SC785	1.00	2SC1293	.85	2SD180	2.75
2SA643	.85	2SC394	.70	2SC789	1.00	2SC1306	4.75	2SD201	1.95
2SA647	2.75	2SC458	.70	2SC793	2.50	2SC1307	5.75	2SD218	4.75
2SA673	.85	2SC460	.70	2SC796	3.15	2SC1308	4.75	2SD235	1.00
2SA679	3.75	2SC478	.80	2SC797	2.50	2SC1317	.60	2SD300	2.50
2SA682	.85	2SC481	1.85	2SC798	3.10	2SC1318	.70	2SD313	1.10
2SA699	1.30	2SC482	1.75	2SC799	4.25	2SC1325	4.95	2SD315	.75
2SA699A	1.45	2SC491	2.50	2SC802	3.75	2SC1327	.70	2SD316	2.50
2SA705	.55	2SC495	1.10	2SC803	4.00	2SC1338	1.75	2SD317	1.25
2SA815	.85	2SC497	1.60	2SC815	.75	2SC1346	.80	2SD318	.95
2SA816	.85	2SC502	1.50	2SC828	.75	2SC1347	.80	2SD325	1.25
		2SC515	.80	2SC829	.75	2SC1364	1.50	2SD341	.95
2SB22	.65	2SC517	4.25	2SC830	1.60	2SC1377	5.50	2SD350	3.25
2SB54	.70	2SC535	.75	2SC838	.70	2SC1383	.75	2SD352	.80
2SB56	.70	2SC536	.65	2SC839	.85	2SC1384	.85	2SD380	5.70
2SB77	.70	2SC537	.70	2SC922	.55	2SC1409	1.25	2SD389	.75
2SB128	2.25	2SC563	2.50	2SC929	.70	2SC1410	1.25	2SD390	.75
2SB152	4.50	2SC607	1.25	2SC930	.65	2SC1447	1.25		
2SB173	.55	2SC614	3.80	2SC938	.85	2SC1448	1.25	2SF8	3.00
2SB175	.55	2SC615	3.90	2SC943	1.50	2SC1449	1.30	2SCF8	3.50
2SB178	1.00	2SC616	4.15	2SC945	.65	2SC1475	1.50	2SCF6	1.25
2SB186	.60	2SC617	4.25	2SC959	3.15	2SC1507	1.25	HEPS3001	3.25
2SB187	.60	2SC620	.80	2SC960	2.75	2SC1509	1.25	JSP7001	.75
2SB235	7.00	2SC627	1.75	2SC984	1.50	2SC1569	1.25	MRF8004	3.00
2SB303	.65	2SC642	3.50	2SC996	4.90	2SC1674	1.25	MPS8000	1.25
2SB324	1.00	2SC643	3.75	2SC1010	.80	2SC1675	1.75	MPS8001	1.25
2SB337	2.10	2SC644	.70	2SC1012	.80	2SC1878	5.50	MPSU02	.50
2SB367	1.60	2SC681	2.50	2SC1013	1.50	2SC1679	4.75	MPSU31	4.00
2SB370	.65	2SC684	2.10	2SC1014	1.50	2SC1756	1.25	SK3047	3.75
2SB405	.85	2SC687	2.50	2SC1017	1.50	2SC1760	2.15	SK3048	3.25
2SB407	1.65	2SC696	3.00	2SC1018	1.50	2SC1816	4.50	SK3049	4.75
2SB415	.85	2SC699	4.75	2SC1030	4.75	2SC1908	.70	SK3054	1.25
2SB461	1.25	2SC710	.70	2SC1051	2.50	2SC1909	4.75	2SK19	.75
2SB463	1.65	2SC711	.70	2SC1060	.75	2SC1957	1.50	2SK30	1.00
2SB471	1.75	2SC712	.70	2SC1061	1.65	2SC1973	1.50	2SK33	1.20
2SB474	1.50	2SC713	.70	2SC1069	3.50	2SC1974	4.90	2SK41	1.75
2SB476	1.25	2SC731	3.00	2SC1079	3.75	2SC1975	4.90	3SK22Y	2.75
2SB481	2.10	2SC732	.70	2SC1080	3.75	2SC2028	1.10	3SK40	2.75
2SB492	1.25	2SC733	.70	2SC1096	1.20	2SC2029	4.75	3SK45	2.75
2SB495	.95	2SC735	.70	2SC1098	1.15	2SC2074	3.00	3SK49	2.75
2SB507	.90	2SC739	.70	2SC1115	2.75			4004	3.00
2SB511	.70	2SC715	.70	2SC1166	.70	2SD45	2.00	4005	3.00
2SB531	3.00	2SC756	3.00	2SC1167	4.25	2SD65	.75	40080	1.25
2SB556	3.50	2SC762	1.90	2SC1170	4.00	2SD68	.90	40081	1.50
2SB135	.95	2SC773	.85	2SC1172B	4.25	2SD72	1.00	40082	3.00

SILICON UNIJUNCTIONS

2N2160	.65	MU4892	.50
2N2846	.45	MU4893	.50
2N2647	.55	MU4894	.50
2N4851	.75	2N6027	.55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	.35
MU4891	.50	MU20	.40

HARDWARE ★ IC SOCKETS

Nylon Screws, Nuts & Rivets (Complete Kit, 50 pc's)	1.99
Trans H/W Mica, Bushings & Screws Case T03, T066 & T0220 (Specify Type, 10 Sets)	1.00
MK20 T03 Complete Mounting Kit	5/.99
MK25 T066 Complete Mounting Kit	5/.99
IC Socket 8 Pin T05 Pkg. of 2	1.00ea.
IC Socket 10 Pin T05 Pkg. of 2	1.22ea.
IC Socket 14 Pin DIL Pkg. of 1	.25ea.
IC Socket 16 Pin DIL Pkg. of 1	.27ea.

RECTIFIERS

	10 For	100 For
IN4001	.60	5.00
IN4002	.70	6.00
IN4003	.80	7.00
IN4004	.90	8.00
IN4005	1.00	9.00
IN4006	1.10	10.00
IN4007	1.20	11.00

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BLOOMFIELD, N.J. 07003
PHONE: (201) 748-6171, 6172, 6173

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All orders add $1.00 Postage $1.50 Canada Dealers Write or Phone for Discount Prices

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PARTIAL LISTING — WRITE FOR FREE CATALOG

CIRCLE NO. 42 ON FREE INFORMATION CARD

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

XR-2260KB Kit $27.95 — XR-2206KA Kit $17.95

EXAR

WAVEFORM GENERATORS		MISCELLANEOUS		TIMERS	
XR-205	$8.40	XR-2211CP	$6.70	XR-555CP	$ .9
XR-2206CP	4.49	XR-4136	.99	XR-320P	1.55
XR-2207CP	3.85	XR-1468	3.85	XR-556CP	1.85
STEREO DECODERS		XR-1488	5.80	XR-2556CP	3.20
XR-1310CP	$3.20	XR-1489	4.80	XR-2240CP	3.25
XR-1310EP	3.20	XR-2208	5.20	**PHASE LOCKED LOOPS**	
XR-1800P	3.20			XR-210	5.20
XR-2567	2.99			XR-215	6.60
				XR-567CP	1.95
				XR-567CT	1.70

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

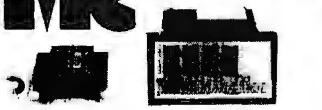
.156 Spacing-Tin-Double Read-Out
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25	PLUG	$3.25
DB25	SOCKET	$4.95

IMC 3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95
B. 5V Power Supply $14.95

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held leatherweight (under one ounce) tool which is used to guide and wrap insulated wire fed off a self-contained replaceable bobbin onto component leads or terminals installed on pre-punched P Pattern Vectorbord. Connections between the wrapped wire and component leads pads or terminals are made by soldering. Complete with 250 FT of red wire **$9.95**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg 3	250 ft. 36 AWG GREEN	$2.40
W36-3-B-Pkg 3	250 ft 36 AWG RED	$2.40
W36-3-C-Pkg 3	250 ft 36 AWG CLEAR	$2.40
W36-3-D-Pkg 3	250 ft 36 AWG BLUE	$2.40

1/16 VECTOR BOARD

	0.1" Hole Spacing Part No.	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

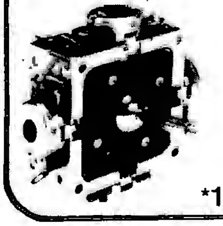
63 KEY KEYBOARD

This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13 x 4 base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four* potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

***5K Pots $6.95**
***100K Pots $7.95**

MICROPROCESSOR COMPONENTS

8080A	CPU	$19.95	MC6800L	8 Bit MPU	$35.00
8212	8 Bit Input/Output	4.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L7	1024 x 8 Bit ROM	18.00
8228	System Controller - Bus Driver	10.95			

CPU'S			RAM'S			
8008	8 BIT CPU	$19.95	1101	256 x 1	Static	$ 2.25
8080	Super 8008	24.95	1103	1024 x 1	Dynamic	1.00
8080A	Super 8008	19.95	2101	256 x 4	Static	5.95
SR'S			2102	1024 x 1	Static	1.75
2504	1024 Dynamic	$ 3.95	2107	4096 x 1	Dynamic	9.95
2518	Hex 32 BIT	7.00	2111	256 x 4	Static	6.95
2519	Hex 40 BIT	4.00	7010	1024 x 1	MNOS	29.95
2524	512 Dynamic	2.49	7489	16 x 4	Static	2.49
2525	1024 Dynamic	6.00	8101	256 x 4	Static	6.95
2527	Dual 256 BIT	3.95	8111	256 x 4	Static	6.95
2529	Dual 512 BIT	4.00	8599	16 x 4	Static	3.49
2532	Quad 80 BIT	3.95	91L02	1024 x 1	Static	2.25
2533	1024 Static	7.95	74200	256 x 1	Static	6.95
3341	Fifo	6.95	93421	256 x 1	Static	2.95
74LS670	16 x 4 Reg	3.95	MM5262	2K x 1	Dynamic	.99
UART'S			**PROMS**			
AY-5-1013	30K Baud	$5.95	1702A	2048	Famos	$12.95
ROM'S			5203	2048	Famos	14.95
2513	Char Gen	$ 9.95	82S23	32 x 8	Open C	5.00
2516	Char Gen	10.95	82S123	32 x 8	Tri state	5.00
74S287	1024-Bit Programmable	1.95	74S287	1024	Static	7.95
			8601	256 x 4	Fast	3.95

"Special Programing Available — BIPOLAR PROM SPECIAL — Write or Call for Pricing"

6330-1	256 Bit (32 x 8) Open Collector	2.95	6306-1	2048 Bit (512 x 4) Three State	9.95
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6300-1	1024 Bit (256 x 4) Open Collector	3.49	6341-1	2048 Bit (512 x 8) Three State	19.95
6301-1	1024 Bit (256 x 4) Three State	3.49	6352-1	4096 Bit (102 x 4) Open Collector	19.95
6305-1	2048 Bit (512 x 4) Open Collector	9.95	6353-1	4096 Bit (1024 x 4) Three State	19.95

Continental Specialties

Proto Board 100 $19.95

THE MINI-BREADBOARD BUDGET KIT

Proto Board 101 — 29.95
Proto Board 102 — 39.95
Proto Board 103 — 59.95
Proto Board 104 — 79.95

COMPLETE KIT

DESIGN MATE 1

CIRCUIT DESIGNER

You asked for it HERE IT IS! CSC's basic circuit designer to help you build and test ANY electronic circuit. Solid #22 AWG wire interconnects any discreet component without solder. Resistors, Transistors, Linear, Digital IC's in TO 5 DIP packages (from 8-40 pins). And more. Components fit directly into Sockets and Bus strips instantly and easily. Plus DE-SIGN-MATE DM-1 (DM 1) variable regulated power supply gives 5-15VDC up to 600mA (9 watts). Now that's design flexibility for you!

$54.95

PROTO BOARD 6

The PB 6 lets the user test and build circuits without soldering or patch cords. All interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit includes 630 component tie points at less than 2.5 cents each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits.

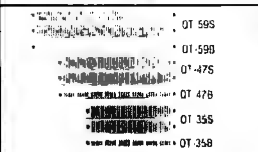
Proto Board 6 $15.95

PC 14		$3.60 ea
PC 16		$3.80
PC 24		$6.10

SPECIAL!

LOGIC MONITOR

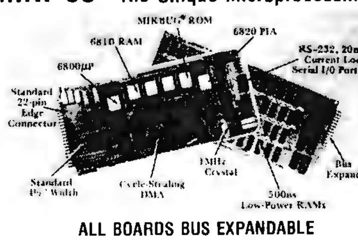
Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs
Pocket size $84.95.



QT Proto Strips

QT type	#holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT 35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

GEMINI-68 The Unique Microprocessing System



ALL BOARDS BUS EXPANDABLE

Uses standard size 4½" wide boards, dual 22 pin edge connector
Fully buffered and tristatable address and data buses

STAND ALONE CPU BOARD — Has 384 bytes of RAM on board, serial I/O (RS-232 and 20 ma current loop, cycle stealing direct memory access (DMA), built in software — selectable echo-back capability. Part # SA-CPU Board **$279.95**

CPU BOARD — Same as above but only has 128 bytes of RAM on board-used with 8K RAM board listed below Part # Gemini 68 CPU Board **$259.95**

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8K EPROM BOARD — Uses 5204 EPROMS by AMI or NATIONAL. Shipped with all decode and miscellaneous IC's, except the 5204 EPROMS Part # Gemini 68 EPROM Board **$ 89.95**

NOT A KIT — ALL BOARDS ARE COMPLETELY ASSEMBLED, BURNED-IN AND TESTED. COMES WITH COMPLETE DOCUMENTATION.

Allow approximately four weeks for delivery

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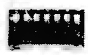
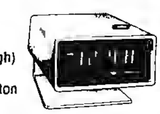
DIP SWITCH



These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications **$1.95**

Timeband™ — A Trademark of Fairchild Camera and Instrument Corporation

DIGITAL ALARM CLOCK $16.95



- 24-Hour Alarm
- "DOZE" Button
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- Large Red Led Display (.8" high)
- AM/PM Indicator
- Seconds Display at touch of button
- SPECIFY BLACK OR IVORY

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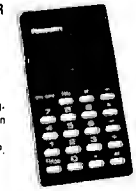
Ladies Watch
- 6 Function
- Bracelet Styling
- 1 Year Guarantee
- Model 900
- Specify Gold or Chrome

$59.95

EXELAR Mens Watch
- 5 Function
- Quartz Crystal
- Black Leather Band
- Manufacturer Guarantee
- Specify Gold or Chrome

$25.00

5 FUNCTION ELECTRONIC CALCULATOR RADOFIN MODEL 8P



$8.95

FEATURES:
- 8 Digit Display
- 5 Functions consists of addition subtraction, multiplication, division, percentage, with constant on all functions with full floating decimal point
- Power source is 1 piece 9V DC Battery 00GP, jack for AC adapter
- Black superfine grained finish plastic cabinet

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One: Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

DIGITAL QUARTZ CAR CLOCK

Complete kit from mounting bracket of the injection molded case down to the three conductor power cord and all components including MM5314 clock chip. Features quartz accuracy of .01%, six digit, .35 high LED display and P C Boards. Works on any 12 volt system — motorcycles, boats, vans, motorhomes, autos and trucks.

Kit: $29.95
Assembled: $39.95

DIMENSIONS 4½ x 4" x 2"
12 or 24 HOUR MODE

CASE ONLY (includes hardware, mounting bracket and bezel) **$5.95**

JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6 x 2½ x 1. It utilizes a MAN72 high brightness readout and the MM5314 clock chip.

115 VAC **$17.95**

This large digit clock (.6" hours & minutes, .3" seconds) features the MM5314 clock chip. It operates from 117 VAC, and will operate in either a 12 or 24 hour mode. The clock is complete with a walnut grain case, and has fast set, slow set, and hold time set features.

JE500 KIT - ALL COMPONENTS & CASE $34.95
WIRED & ASSEMBLED $39.95

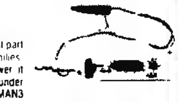
DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95 — **4 DIGIT ASSEMBLED $59.95**
6 DIGIT KIT $69.95 — **6 DIGIT ASSEMBLED $79.95**

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

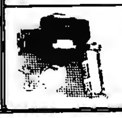
JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit
printed circuit board

T²L 5V 1A Supply



This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware, for only **$9.95 Per Kit**

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SN7402N	.17
SN7404N	.19
SN7410N	.17
SN7414N	63
SN7420N	.17
SN7430N	.20
SN7440N	.17
SN7447N	.60
SN7450N	.17
SN7473N	.36
SN7474N	.32
SN7475N	.49
SN7489N	2.00
SN7490N	.45
SN7492N	45
SN7493N	.49
SN74100N	.90
SN74107N	39
SN74121N	39
SN74145N	69
SN74150N	.95
SN74151N	75
SN74154N	1.10
SN74157N	.65
SN74174N	1.19
SN74175N	80
SN74193N	85
SN74285N	6.00
SN74298N	1 65

74LS00 TTL	
SN74LS00N	34
SN74LS02N	34
SN74LS04N	39
SN74LS08N	39
SN74LS10N	39
SN74LS20N	.34
SN74LS26N	41
SN74LS30N	.34
SN74LS38N	39
SN74LS74N	59
SN74LS75N	.75
SN74LS90N	1.10
SN74LS93N	1.10
SN74LS95N	1.89
SN74LS107N	.52
SN74LS163N	2.05
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LM308N	.89
LM309K	.95
LM311H	.90
LM318	1.35
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LM323K-5	6.95
LM320T-5	1.60
LM320T-8	1 60
LM320T-12	1.60
LM320T-15	1.60
LM324N	1.10
LM339N	1.55
LM340K-5	1.60
LM340T-5	1.50
LM340T-8	1.70
LM340T-12	1 70
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LM709H	.28
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LM3900N	.55
LM3909N	.69
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NE555V	.43
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NE565A	1.00
NE566V	1.85
NE567V	1.25
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SN75452CN	.39
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CD4012	.25
CD4013	.40
CD4014	1.25
CD4015	1.25
CD4016	.50
CD4017	1.00
CD4020	1.35
CD4021	1.20
CD4023	.25
CD4024	85
CD4025	.25
CD4026	3.65
CD4027	.55
CD4029	1.70
CD4030	.42
CD4040	1.35
CD4042	1 50
CD4043	2.00
CD4044	2.00
CD4049	.62
CD4050	.55
CD4066	85
CD4068	25
CD4069	.40
CD4071	.40
CD4072	.40
CD4073	40
CD4075	40
CD4076	1 75
CD4078	40
CD4081	.40
CD4082	.45
CD4508	4.25
CD4510	2.00
CD4511	2.20
CD4515	4.00
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CD4583	4.50
CD4585	2.10
CD40192	3.00
74C00	.28
74C04	33
74C10	.28
74C14	2.10
74C20	28
74C30	28
74C48	2.95
74C74	75
74C106	2 10
74C160	2.00
74C192	2.40
74C221	2.75
74C906	1 50
74C925	10 50
74C926	10.50
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8096	.75
8097	75
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MM5309	3.90
MM5311	3 60
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MM5314	3.90
MM5315	4.00
MM5316	5 00
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Complete clock module minus transformer and switches

MA1002A, C, E 50"	$8.95
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4 digit, 7 function stop-watch/timer circuit, new National MM5865
$9.00 Board available.
10 page spec only, $1.00

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Solder Tin Low Profile

PIN	1 UP	PIN	1UP
8	.15	24	.38
14	.18	28	.43
16	20	36	58
18	27	40	61
22	.35		

MICROPROCESSOR	
8080 with data	19 00
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Intersil 7205 chip with 6 digit readout PC board, complete instructions, all parts minus case

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3 Digit Universal Counter Board Kit
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12 Volt 300 ma transformer	1.25

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Yellow T018	.20
Jumbo Red	.20
Jumbo Green	25
Jumbo Yellow	25
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MAN1	CA	270	2.90
MAN3	CC	125	.39
MAN6640 Dual	CC	500	3.50
MAN72	CA	300	1 50
MAN74	CC	.300	1.50
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DL707	CA	300	1.50
DL727	CA	.500	2.55
DL747	CA	600	2.25
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FND503	CC	500	1.00
FND510	CA	500	1.00
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1 MHz	4.50	6.5536	4 50
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4 MHz	4 25	2 097152	7 75
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18 MHz	3.90	5 0688	4 50
20 MHz	3.90	5.185	4.50
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32768 Hz	4.00	18 432	4 50
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TV GAME CHIPS
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Data Access Arrangement Kit, Instr Incl 10 00

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		1	100
MM5262	2K RAM	90	50
MM5369	Divider	2 10	1 40
2102-1	500 NS 1K RAM	1 80	1 30
MM5375AA	Alarm Clock	3 75	2 20
FND503	50" Display	1 20	89
18MHz	Crystal	3 90	2 50
PD411-4	150 NS 4K RAM	8 00	5 75
MA1002E	5 Alarm Clock Mod	8 95	7 80
MA1013E	7 Alarm Clock Mod	10 95	8 95
MM5309	Clock	3 90	2 70
MM5314	Clock	3 90	2 70

Other parts also avail

8K Ram Board Kit

- Plug compatible with Altair 8800 and Imsai 8080
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Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy. Kit includes: PC board, MM5369, crystal, resistors, capacitors and trimmer.

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Indoor and outdoor. Automatically switches back and forth. Beautiful. 50" LED readouts. Nothing like it available. Needs no additional parts for complete, full operation. Will measure −100° to +200°F, air or liquid. Very accurate. Easy to build. $39.95

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Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. Same clock kit with .80" displays $22.75

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Covers audio, ultrasonic and low amateur band to 5 MHz typical Dual channel high sensitivity ±25 millivolts. Crystal controlled clock. Can be prescaled for higher frequency. 6-.50" digits. Full instructions. Less power supply. $40.00

COSMAC 'ELF'

RCA CMOS Microcomputer
CDP1802 $29 50 Users Manual 7 50
Complete kit of parts to build the "Elf" incl. CDP 1802 and users manual as listed in Aug. '76 Pop. Elect. minus power supply and board. $92.00

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Our first power supply kit was introduced almost two years ago and is still the most popular. A compact, well regulated triple output power supply. Gives +5VDC @ 1.5A and +15 @ 150 MA and −15 @ 150MA. The PS-01A uses the superior 78L series of three terminal regulators. Complete with P.C.Board, all components, heatsinks and quality tranformer. $14.95

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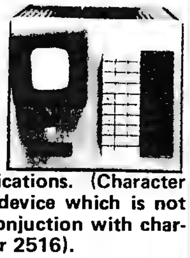

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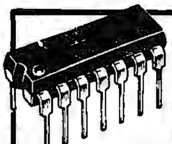

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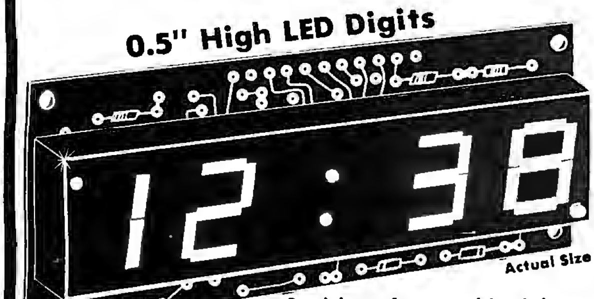

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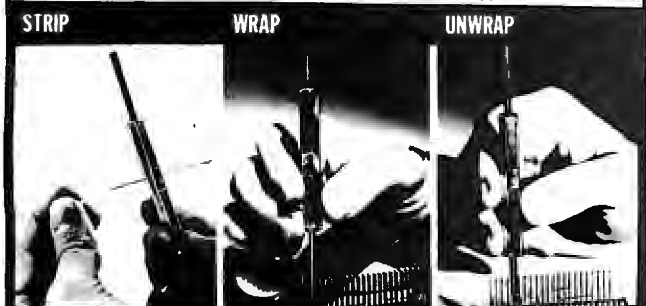

MA1002 & MA1010 Series Electronic Clock Modules
NATIONAL

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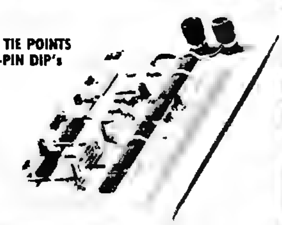

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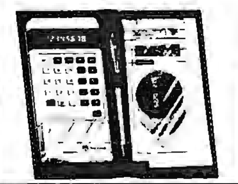

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1/50V 08	.65/10	100/6.3V. .09	.75/10	470/10R . . 21	1.71/10
2.2/50V. . .08	.65/10	100/10V. . 10	.77/10	470/16V . . 23	1.81/10
3.3/50V. . .08	.65/10	100/16V . .11	.85/10	470/25V . . 29	2.35/10
4.7/35V. . .08	.65/10	100/25V. . 13	1.10/10	1000/10V . 24	1.96/10
4.7/50V. . .08	.68/10	100/50V. . 21	1.71/10	1000/16V . 29	2.35/10
10/16V . . .08	.65/10	220/10V. . 13	1.08/10	1000/25V . 42	3.33/10
10/25V . . .08	.65/10	220/16V. . .15	1.16/10	2200/10V . 42	3.33/10
10/50V . . .10	.75/10	220/25V. . 21	1.71/10	2200/16V . 54	4.30/10
22/16V . . .08	.67/10	220/50V. . 29	2.35/10	2200/25V . 58	4.67/10
22/25V . . .09	.70/10	330/10V. . 15	1.16/10	3300/16V . 89	7.14/10
		330/16V. . 21	1.66/10		

AXIAL ELECTROLYTICS

.47/10V . . 11	.90/10	33/25V. . . 14	1.15/10	330/16V . . 29	2.35/10
1/30V . . . 11	.90/10	33/50V. . . 19	1.52/10	330/25V . . 32	2.54/10
3.3/35V . . 12	.95/10	47/16V. . . 14	1.15/10	470/16V . . 32	2.55/10
3.3/50V . . 12	1.00/10	47/25V. . . 17	1.30/10	470/25V . . 37	3.00/10
4.7/25V . . 11	.90/10	47/50V. . . 21	1.17/10	1000/10V . 33	2.65/10
4.7/35V . . 12	.95/10	100/10V. . 14	1.13/10	1000/16V . 39	3.15/10
4.7/50V . . 12	1.00/10	100/16V. . 17	1.30/10	1000/25V . 56	4.50/10
10/25V. . . 12	1.00/10	100/25V. . 20	1.55/10	2200/10V . 50	3.96/10
10/50V. . . 14	1.15/10	100/50V. . 29	2.30/10	2200/16V . 62	4.95/10
22/16V. . . 12	1.00/10	220/10V. . 18	1.42/10	2200/25V . 79	6.36/10
22/25V. . . 13	1.05/10	220 16V. . 20	1.55/10	3300/16V . 95	7.63/10
22/50V. . . 17	1.32/10	220 25V. . 29	2.35/10	4700/16V 1.09	8.70/10
33/16V. . . 12	1.00/10	220/50V. . 40	3 23/10	10000/10V 1.15	9.19/10
		330 10V. . 14	1 16/10		

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7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74188	3.50	4016	.40	2102-1	1.99
7405	.21	7486	.28	74189	3.50	4017	1.05	8080A	24.95
7406	.25	7489	2.19	74190	1.23	4018	1.05	CA3046	.75
7407	.25	7490	.44	74191	1.23	4019	.23	LM2111N	1.25
7408	.21	7491	.70	74192	.88	4020	1.14	LM309K	1.80
7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
7410	.21	7493	.44	74194	.88	4022	.96	LM340T-5	1.25
7411	.21	7494	.70	74195	.88	4023	.23	LM340T-6	1.25
7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.88	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82525	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

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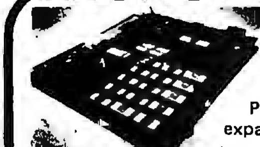

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LM105	3.50	LM320K 5.2	1.45	LM381N	1.79
LM108H	2.50	LM320K 12	1.45	LM382N	1.79
LM300H	.80	LM320K 15	1.45	LM555CN	.58
LM301H	.45	LM320T 5	1.75	LM556CN	1.30
LM301CN	.45	LM320T 5.2	1.75	LM567CN	1.45
LM302H	1.25	LM320T 8	1.75	LM566N	1.95
LM304H	1.20	LM320T 12	1.75	LM565H	1.95
LM305H	.85	LM320T 18	1.75	LM703CN	.45
LM305AH	1.25	LM232K 5	9.95	LM709H	.40
LM308N	.95	LM324M	1.65	LM709N	.40
LM307CN	.35	LM339N	1.55	LM710N	.70
LM307H	.35	LM340K 5	1.95	LM711N	.39
LM308H	1.00	LM340K 8	1.95	LM711H	.39
LM308CN	1.00	LM340K 12	1.95	LM723N	.55
LM309H	1.10	LM340K 15	1.95	LM723H	.55
LM309K	1.25	LM340K 18	1.95	LM725H	3.25
LM310CN	1.15	LM340K 24	1.95	LM733N	1.00
LM310H	1.15	LM351CN	.65	LM733CH	1.45
LM311H	.90	LM370N	1.65	LM739N	1.29
LM311CN	.49	LM370H	1.65	LM741CH	.35
LM312H	1.95	LM373N	3.25	LM741CN 14	.39
LM318H	1.50	LM377N	4.00	LM741CD	.49
LM318CN	1.50	LM380N	1.39	LM747H	.75
LM319N	1.30	LM380CN	1.05	LM747N	.75
LM320K 5	1.45			LM748H	.39
				LM748N	.39

LM1414N	1.75	75324	3.50
LM1458CN	.65	SG4501T	2.40
LM1496N	.95	SG4501N	2.40
LM2111N	1.95	SG3524	6.95
LM2901N	1.95	RC4194T	6.95
LM3065N	.69	RC4195T	6.95
LM3900N	.55	RC1458CN	.89
LM3909	1.10	RC1556CN	.99
LM7520	2.25	RC3403AD	2.30
LM7524N	1.75	RC4131CN	.99
LM7525N	1.90	RC4136D	1.90
LM7534N	2.70	RC4558CN	.99
LM7535N	1.25	RC4151CN	6.50

★ CMOS

CD4000	.25	CD4026	1.95	CD4075	.35
CD4001	.25	CD4027	.85	CD4078	.35
CD4002	.25	CD4028	1.50	CD4081	.35
CD4006	1.75	CD4029	1.99	CD4082	.35
CD4007	.25	CD4030	.60	CD4510	1.95
CD4008	1.95	CD4033	2.49	CD4511	1.40
CD4009	.48	CD4034	4.95	CD4516	1.95
CD4010	.48	CD4035	1.79	CD4518	2.45
CD4011	.28	CD4040	2.10	CD4520	2.49
CD4012	.28	CD4042	1.45	CD4522	2.56
CD4013	.60	CD4043	1.45	CD4526	2.56
CD4014	1.95	CD4044	1.95	CD4527	2.70
CD4015	1.95	CD4049	.61	CD4528	1.50
CD4016	.59	CD4050	.61	CD4531	1.99
CD4017	1.25	CD4051	2.25	CD4543	2.25
CD4018	2.29	CD4066	1.20	CD4555	1.75
CD4019	1.95	CD4068	.35	CD4556	1.75
CD4020	1.35	CD4069	.35	CD4581	4.95
CD4021	1.85	CD4070	.99	CD4582	1.95
CD4023	.29	CD4071	.35	CD4585	2.45
CD4024	1.29	CD4072	.35	Also	
CD4025	.29	CD4073	.35	5101	$11.95

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7402N	.18	7447N	.99	74125N	.79	74191N	$1.30		
7403N	.18	7448N	.99	74126N	.79	74192N	$1.10		
7404N	.19	7450N	.26	74132N	.70	74193N	$1.10		
7405N	.20	7451N	.26	74141N	.88	74194N	.95		
7406N	.25	7453N	.26	74145N	.70	74195N	.95		
7407N	.25	7454N	.26	74147N	$1.50	74196N	.95		
7408N	.21	7470N	.45	74148N	$1.29	74197N	.95		
7409N	.21	7472N	.30	74150N	$1.15	74198N	$1.45		
7410N	.31	7473N	.30	74151N	.88	74199N	$1.65		
7411N	.21	7474N	.30	74153N	.90	74251N	$1.45		
7412N	.21	7475N	.69	74154N	$1.15	74279N	$1.10		
7413N	.45	7476N	.42	74155N	.95	8083N	.40		
7414N	.69	7480N	.70	74156N	.95	8094N	.49		
7416N	.35	7482N	.95	74157N	.95	8095N	.99		
7417N	.35	7483N	.95	74160N	.99	8096N	.99		
7420N	.19	7485N	.89	74161N	.99	8097N	.99		
7421N	.35	7486N	.29	74162N	.99	8098N	.99		
7423N	.35	7489N	$1.99	74163N	.99	75150N	$1.70		
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7432N	.31	7495N	.79	74173N	$1.40	75491N	.70		
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7440N	.21	74104N	.53	74177N	.79				
7441N	$1.08	74105N	.53	74180N	.79				
7442N	.88	74107N	.33	74181N	$2.75				
7443N	.88	74108N	.33	74182N	.79				
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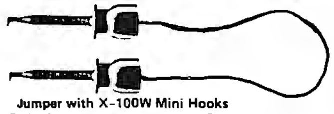

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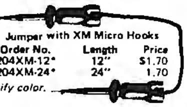

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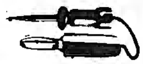
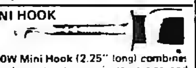


Order No.	Length	Price
201XM*	32"	$1.40

MINI HOOK



X100W Mini Hook (2.25" long) combines rugged construction, miniature size and Finger-eze Hypo Action for all the best test connections. Hook is large enough for component leads, yet small enough to get into tight places . . . . . $.75 ea.

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Jumper X-100W Mini Hook to Stacking Banana Plug**

Order No.	Length	Price
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XL-1 Mini Hook (5.0" long) combines all the proven features of the X100W with an extra long body. It will make safe, short-free test connections in card racks and through deep wiring nest up to 4". . . . . $1.25 ea

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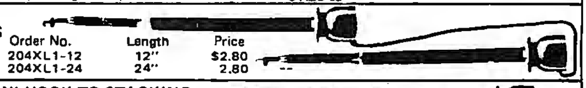
JUMPER WITH XL-1 MINI HOOKS



Specify Color

Order No.	Length	Price
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204XL1-24	24"	2.80

JUMPER, XL-1 MINI HOOK TO STACKING BANANA PLUG

Specify color

Order No.	Length	Price
201XL-1*	32"	$1.95

**Specify color* ***Square hole tip for hooking laterally to leads or vertically over square wire-wrap pins.*

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14 Pin	0.19	0.18	0.17	20 Pin	0.34	0.33	0.32	36 Pin	0.59	0.58	0.57
16 Pin	0.21	0.20	0.19	22 Pin	0.36	0.35	0.34	40 Pin	0.62	0.61	0.60
				24 Pin	0.37	0.36	0.35				

STANDARD, SOLDER, TIN	1-24	25-49	50-100	STANDARD, SOLDER, GOLD	1-24	25-49	50-100	WIREWRAP GOLD (Level No.3)	1-24	25-49	50-100
8 Pin	0.25	0.23	0.22	8 Pin	0.30	0.27	0.24	10 Pin	0.45	0.41	0.37
14 Pin	0.27	0.25	0.24	14 Pin	0.35	0.32	0.29	14 Pin	0.39	0.38	0.37
16 Pin	0.30	0.27	0.25	16 Pin	0.38	0.35	0.32	16 Pin	0.43	0.42	0.41
18 Pin	0.35	0.32	0.30	18 Pin	0.52	0.47	0.43	18 Pin	0.75	0.68	0.62
22 Pin	0.70	0.65	0.60	22 Pin	0.70	0.63	0.57	24 Pin	1.05	0.95	0.85
24 Pin	0.49	0.45	0.42	24 Pin	0.70	0.63	0.57	28 Pin	1.40	1.25	1.10
28 Pin	0.99	0.90	0.81	28 Pin	1.10	1.00	0.90	36 Pin	1.59	1.45	1.30
36 Pin	1.39	1.26	1.15	36 Pin	1.75	1.40	1.26	40 Pin	1.75	1.55	1.40
40 Pin	1.59	1.45	1.30	40 Pin	1.75	1.59	1.45				

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74C10N	.50	74C86N	1.00	74C163N	2.10	74C903N	1.00
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74C20N	.50	74C90N	2.70	74C165N	1.80	74C906N	1.00
74C30N	.50	74C93N	2.70	74C173N	1.80	74C907N	1.00
74C32N	.50	74C95N	1.80	74C174N	1.70	74C914N	2.70
74C42N	2.10	74C107N	1.90	74C175N	1.70	80C95	1.00
74C48N	3.30	74C151N	3.80	74C192N	2.10	80C97	1.00
74C73N	1.20	74C154N	5.70	74C193N	2.10		

CMOS

4000AE	.20	4023AE	.24	4051AE	1.70	4093AE	1.65
4001AE	.24	4024AE	.95	4052AE	1.40	4095BE	1.95
4002AE	.24	4025AE	.24	4053AE	1.70	4098AE	2.50
4006AE	1.30	4026AE	2.60	4055AE	1.95	4099AE	2.90
4007AE	.24	4027AE	.55	4056AE	1.99	4502AE	1.50
4008AE	1.40	4028AE	1.00	4060AE	2.10	4507BE	.60
4009AE	.50	4029AE	1.20	4063AE	2.50	4508BE	2.20
4010AE	.50	4030AE	.48	4066AE	.90	4510AE	1.40
4011AE	.24	4033AE	2.00	4068AE	.44	4511BE	1.30
4012AE	.24	4035AE	1.30	4069AE	.44	4512BE	1.30
4013AE	.40	4040AE	1.20	4070BE	.60	4514AE	5.00
4014AE	1.20	4041AE	1.25	4071AE	.45	4515AE	5.00
4015AE	1.30	4042AE	1.20	4072AE	.34	4516AE	1.75
4016AE	.80	4043AE	.95	4073AE	.40	4518AE	1.50
4017AE	1.05	4044AE	1.10	4075AE	.40	4520AE	1.28
4018AE	1.24	4046AE	3.10	4076AE	1.24	4528AE	2.20
4019AE	.54	4047AE	2.50	4077AE	.40	4586AE	2.05
4020AE	1.45	4048AE	1.43	4078AE	.40	4901AE	.32
4021AE	1.30	4049AE	.58	4081BE	.40	4911AE	.32
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Only in Multiples of 100 pcs per value (ohms)

¼W . . . $1.69 per 100

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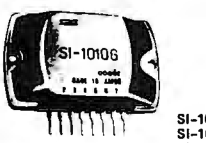
10	100	1.0K	10K	100K	1.0M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2.0K	20K	200K	2.0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6.8M
75	750	7.5K	75K	750K	7.5M
82	820	8.2K	82K	820K	8.2M
91	910	9.1K	91K	910K	9.1M

SANKEN HYBRID AUDIO POWER AMPLIFIERS



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- Asst.4: 3.3K, 3.9K, 4.7K, 5.6K, 6.8K, 8.2K, 10K, 12K, 15K, 18K
- Asst.5: 22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 120K
- Asst.6: 150K, 180K, 220K, 270K, 330K, 390K, 470K, 560K, 680K, 820K
- Asst.7: 1M, 1.2M, 1.5M, 1.8M, 2.2M, 2.7M, 3.3M, 3.9M, 4.7M, 5.6M* (½W Assortment No.7 doesn't include 5.6M)
- Asst.8R: (All seven assortments above) ¼W,5%,350 pcs total: $10.95 - ½W,5%,350 pcs total: $11.55

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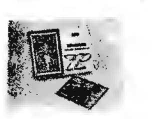
Model No.	Output Vdc	Output Amps	Price
APS5-3	5	3.0	30.95
APS12-1.6	12	1.6	
APS15-1.5	15	1.5	
APS24-1	24	1.0	
APS28-0.8	28	0.8	
APS5-6	5	6	60.40
APS12-4	12	4	
APS15-3	15	3	
APS24-2.2	24	2.2	
APS28-2	28	2	
APS5-10	5	10	71.20
APS12-7	12	7	
APS15-6	15	6	
APS24-5	24	5	
APS28-4	28	4	
DAPS12-.75	±12	.75	41.50
DAPS12-.60	±15	.60	
DAPS12-1.5	±12	1.5	55.10
DAPS15-1.3	±15	1.3	

XR FUNCTION GENERATOR



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.15	35	.33	6.8	35	.45
.22	35	.33	10.0	16	.42
.33	35	.33	10.0	25	.45
.47	35	.33	10.0	35	.90
.68	35	.33	15.0	20	.45
1.0	35	.33	15.0	35	1.32
1.5	35	.40	22.0	16	.45
2.2	20	.33	33.0	20	1.32
2.2	35	.40	47.0	20	1.53
3.3	35	.42	68.0	16	1.62
4.7	35	.45			

PLESSEY POLYESTER (CAPACITOR) MINI BOX

MF	V	$	MF	V	$
.001	1000	.14	.039	250	.15
.0012	1000	.14	.047	250	.15
.0015	1000	.14	.056	250	.15
.0018	1000	.14	.068	250	.15
.0022	1000	.14	.082	250	.17
.0027	1000	.14	.1	100	.17
.0033	1000	.14	.12	100	.18
.0039	630	.14	.15	100	.20
.0047	630	.14	.18	100	.21
.0056	630	.14	.22	100	.23
.0068	630	.14	.27	100	.26
.0082	630	.14	.33	100	.30
.01	630	.14	.39	100	.33
.012	630	.14	.47	100	.36
.015	400	.15	.56	100	.44
.018	400	.15	.68	100	.47
.022	400	.15	.82	100	.54
.027	400	.15	1.0	100	.60
.033	250	.15			

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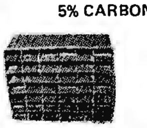

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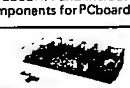

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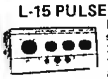

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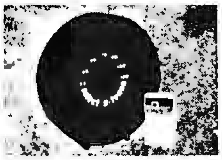

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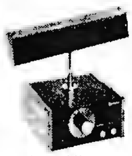

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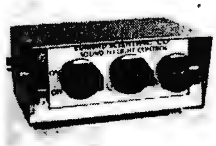

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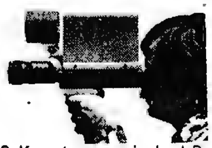

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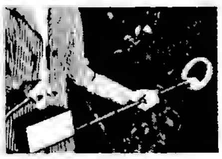

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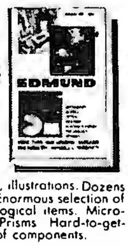

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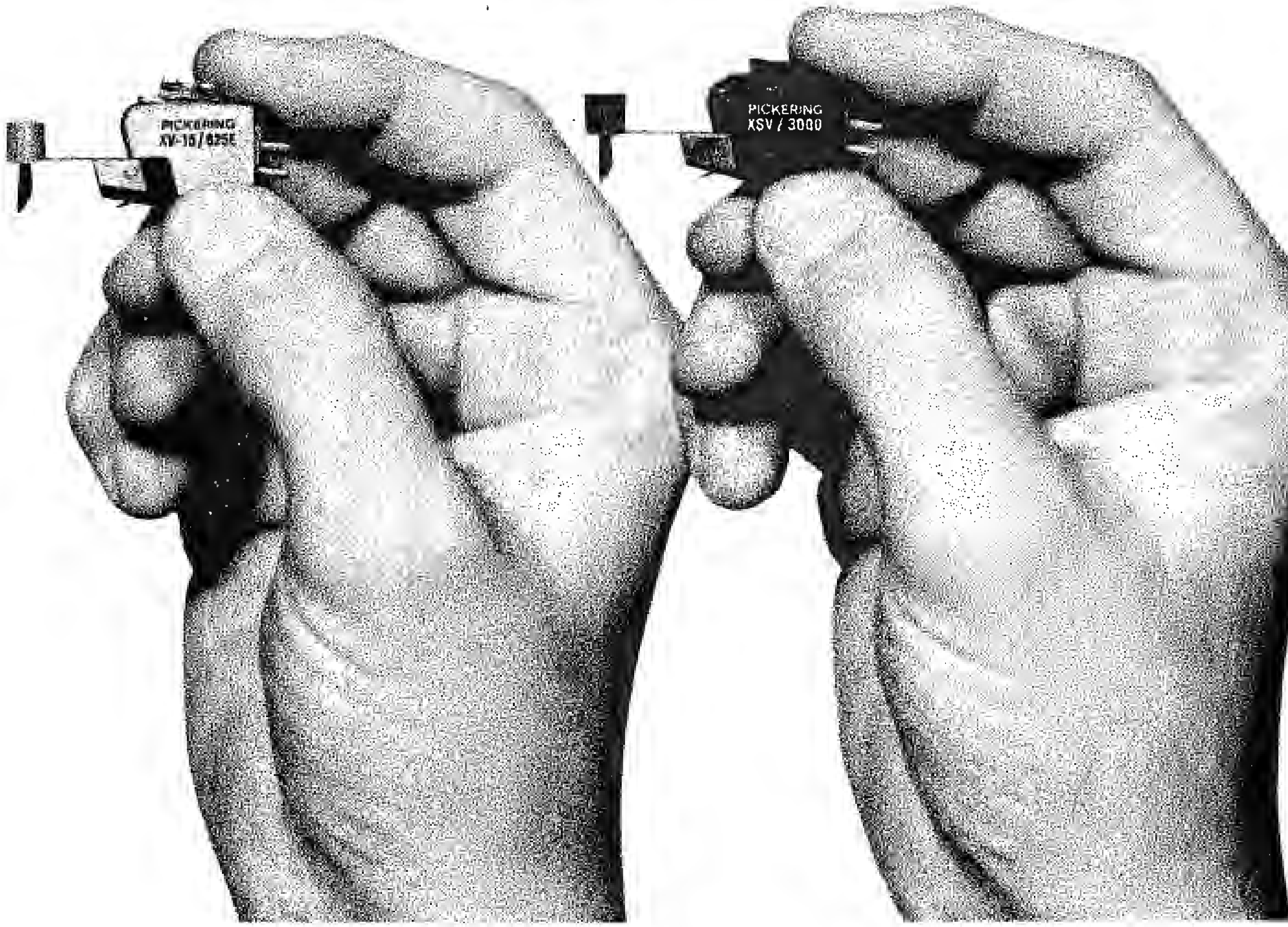

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We'll let someone else tell you how good our belt-drive turntables really are.

"...in the same class with a number of more expensive products, including many of the direct-drive record players we have seen."

This quote, from the Hirsch-Houck Labs' report in *Stereo Review*, refers to the Dual 510, a semi-automatic belt-drive turntable. Since direct-drive models (especially our own) are accepted as *the* standard of performance, Hirsch-Houck's comparison is not to be taken lightly.

The 510 also benefits from comparison with other semi-automatic turntables. Dual's unique sensor locates the 12-inch and 7-inch lead-in grooves for you. You don't have to guess where they are. And there's no way to drop the tonearm accidentally; the cue-control lifts it automatically at the end of play and supports it until you release it.

You might also compare the 510 with your present turntable, or any other you may be considering. When you do, keep in mind the 510's many other features and refinements described below. Your old records will sound better, your new ones last longer.

Dual **United Audio Products,** 120 So. Columbus Ave., Mt. Vernon, N.Y. 10553

Dual 510. Semi-automatic, single-play. True four-point gimbal tonearm suspension. Synchronous motor, precision-ground belt, unique Vario-pulley, dynamically-balanced platter. 6% pitch-control, illuminated strobe. Lead-in groove sensor. Cue-control viscous-damped in both directions. Less than $200.
Dual 502. Similar except less sensor, pitch-control and strobe. Less than $160.
Dual 1249, fully automatic single-play/multi-play. Less than $280.

True four-point gimbal centers and pivots the tonearm mass at intersection of horizontal and vertical axes. Tonearm is dynamically balanced in all planes. The four needle-point pivots are first hardened, then honed, a process which produces microscopically smooth surfaces. The precision ball-bearing races are only 0.157 inch diameter. Bearing friction: vertical, <0.007 gram; horizontal, <0.015 gram.

Stylus force, applied by long coiled spring around vertical pivot, remains perpendicular to record even if turntable is not level.

Unique Vario-pulley used in Dual's three belt-drive models is precision-machined for perfect concentricity and balance. Speeds are adjusted by expansion and contraction of pulley circumference; belt is never twisted or distorted.

Specifications (DIN B): Rumble, >63dB; Wow and flutter, <±0.05%.

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